Fourth Report of the Laguna Marine Laboratory

and Contributions from the Zoological Laboratory of Pomona College

FOURTH REPORT OF THE LAGUNA MARINE LABORATORY AND CONTRIBUTIONS FROM THE ZOOLOGICAL LABORATORY OF POMONA COLLEGE

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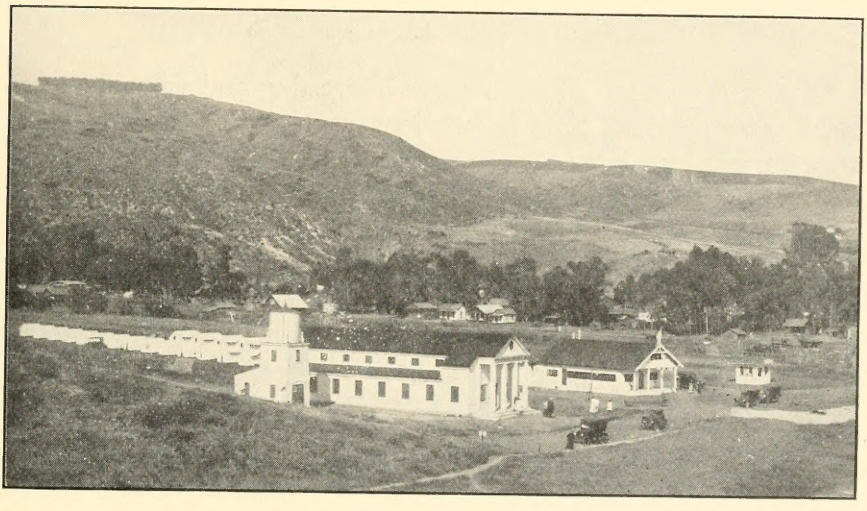
Summer School at Laguna Beach

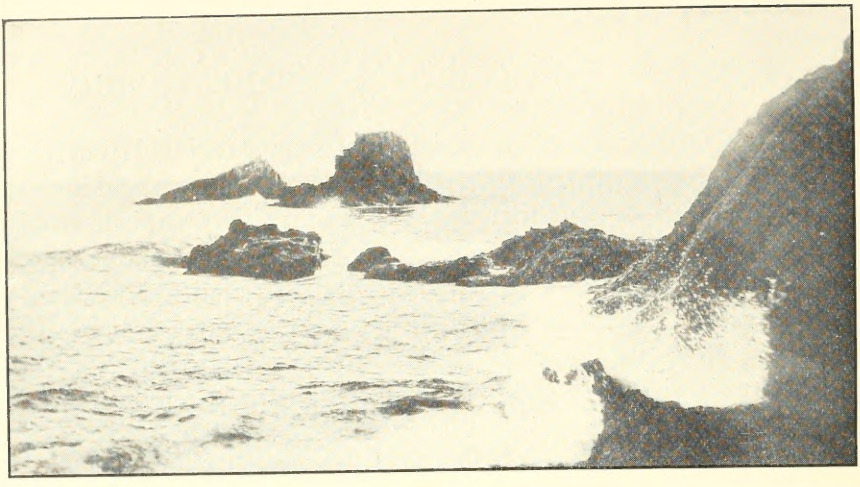
Once more the advantages of the Laguna Marine Laboratory have been enjoyed by a considerable number of students and investigators. During the summer of 1915 about thirty students registered for courses in Marine Zoology, Entomology and General Biology. There were also a number of the students who took special work. In addition to these in various courses, there were about twelve students and investigators from eastern and northern colleges and universities, who stayed a day, a week, a month and in some cases for longer periods throughout the summer.



Laguna Marine Laboratory and Tent City

The new tent city with its rooming and housekeeping tents, and dining hall for the first time furnished ample accommodation at a reasonable price to all who stayed at the Summer School or visited the Laboratory.

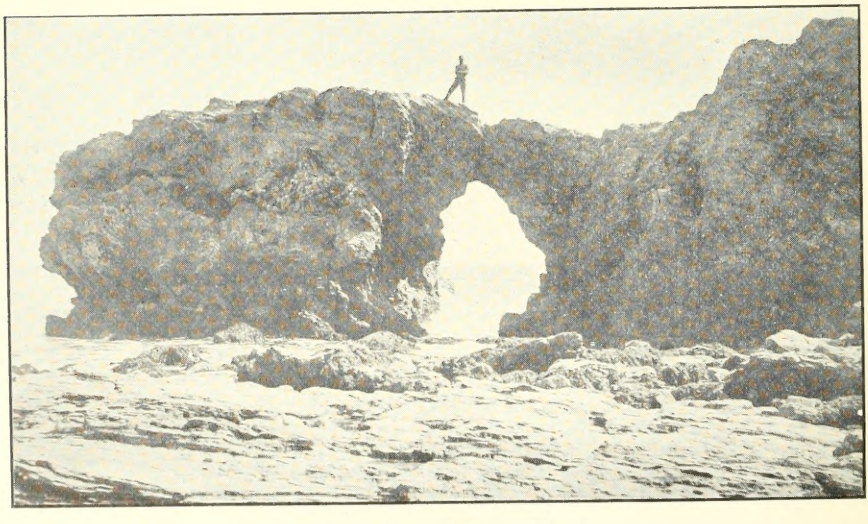
In the aquarium room an exhibition of local animals was open at all times. During the season over two thousand people visited the aquarium and museum. Evening lectures were given during the Summer School and these were always open to the public.



Near Two-Rock Point, Laguna Beach

During the season of 1915 more interesting and valuable specimens were obtained than in previous years. Very few of these have yet been worked over for publication.

The beautiful coast line, both up and down from the Laboratory, was more extensively explored than in other years, yet there are many places not carefully examined at low tide. Inland also more



An Arch Above Laguna Beach

field trips were taken, to canyons, to caves, to hill-tops and along streams. The Lakes up Laguna Canyon were found to be almost as interesting as the rocks at low tide. There was not time last summer to any more than to begin to touch the possibilities of the region.

It is rather interesting to note that the students as a whole did better class work than in Claremont. This may partly be due to lack of pressure of outside activities, and partly due to the enthusiasm developed by the study of animals in their natural environment, but still there were some diversions which helped to pass the time pleasantly. Saturday was used for the more or less optional field exercises. Early mornings when the tide was low were also used for field work. After four P. M. every day, time was usually taken for bathing or short walks and on some evenings there were beach suppers.

During the coming summer more courses will be offered and a number of visitors and investigators are expected.

The tent city and dining hall will again offer accommodations at reasonable prices. The cost of tuition will be as last year; that is, $7.50 general charge and $2.00 an hour per hour taken. By an hour is meant the equivalent of an hour's work in a regular college semester. There are eight private rooms for special investigators.

For further information write to the Director, William A. Hilton, Pomona College, Claremont, Cal. (Laguna Beach, Cal., from June 22 to September 20.)

Courses Offered at the Summer School of the Laguna Beach Biological Laboratory 1916

To reach Laguna Beach from Los Angeles take the electric or Santa Fe to Santa Ana. From Santa Ana a morning stage leaves at ten, an afternoon stage at four.

Work begins June 26th and regular courses last six weeks, but the laboratory is open all summer.

No one may register for more than six hours. By an hour is included the equivalent of an hour's work during a regular college semester.

1. S. B. 11. Zoology (2 hours). A synopsis of marine invertebrates. Lectures and class exercises with early morning field trips. Prerequisite Biology A1, or open to those who are taking some other biological work. M. to F. at 8. Prof. W. A. Hilton and ————.

1a. S. B. 11. Zoology. Marine invertebrates (1 hour if taken with 1, or 2 hours). Laboratory on typical local forms. Mornings 9 to 12, except Saturday. Prof. W. A. Hilton and ————.

2. S. B. 18. General Entomology (2 to 3 hours). Class laboratory and field work in the general study of local insects. Prerequisite Biology A1, or Zoology B11, or may be accompanied by one of these. Class period M. to F. at 11. Lab. and field work at hours to be arranged. Prof. W. A. Hilton and ————.

3. S. A1. General Biology (3 hours). A beginning course dealing with general principles. Open to those who have had no biological work and who have either entered college or are about to enter. Class periods M. to F. at 1. Lab. and field work afternoons. Prof. W. A. Hilton and ————.

4. S. C. 4. Ecology (2 or 3 hours). Class field and laboratory work at hours to be arranged. A study of local land and aquatic societies and the factors governing the distribution of marine, fresh water and land forms. Prerequisite, a year of biological work. Prof. A. M. Bean.

5. S. C. 5. Seaweeds (2 or 3 hours). Chiefly a study of marine Algæ. Prerequisite a good general course in Botany. M. to F. at 8. Field and laboratory work at hours to be arranged. Prof. A. M. Bean.
6. S. B. 6. Birds (2 hours). This course is designed to acquaint the student with the birds of Southern California—their classification, habits, haunts and songs. Some attention will be given to structure, development, and the problem of migration. Emphasis will be laid upon their economic relations. Lectures three times a week. Laboratory and field work to be arranged. Prerequisite one year of biological work. Prof. H. H. Nininger.
7. S. D. 7. Mammalian Embryology (2 hours). Lab. work with serial sections of embryos. Prerequisite two years of zoological work. A review course for those in the practice of medicine or preparing for medical work. Hours to be arranged.
8. S. D. 8. Human Neurology (2 hours). Laboratory work with sections of the human brain and cord. A review course open only to those who have some knowledge of the central nervous system of vertebrates. Especially designed for those who have interest in Neurology, Psychology or Medicine.

In addition to these courses special C. or D. work for 2 or 3 hours may be taken as follows:

a. Special field and laboratory work with some group of marine animals, such as amphipods, isopods, decapods, gastropods, etc.
b. Special field and laboratory work in Entomology, either with some single order or family, or life history work.
c. Special field and laboratory work in the embryology of invertebrates.
d. Special field and laboratory work in Ecology. Hours to be arranged.
e. Special field and laboratory work in marine algæ. Hours to be arranged.

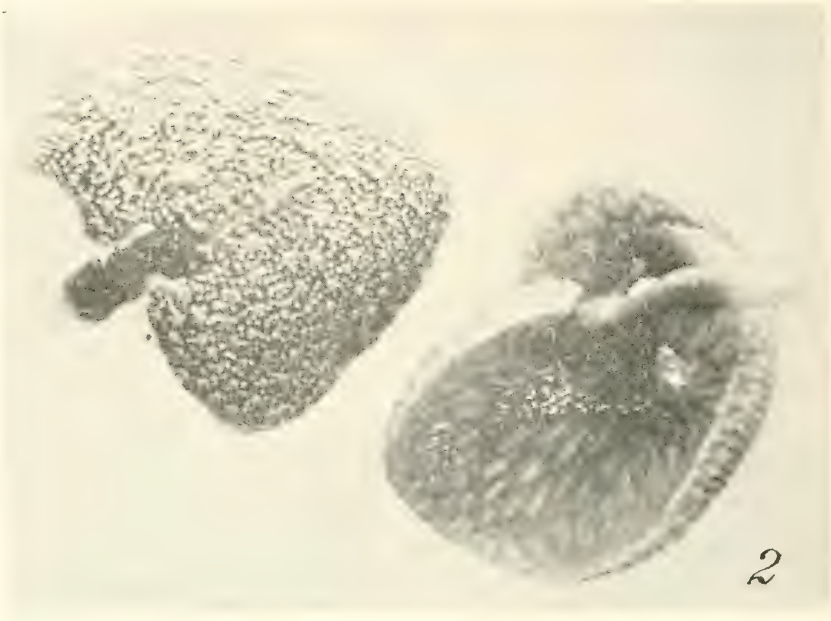
There will be, as last summer, special nature-study work given to younger pupils. Adapted for children from nine to fifteen.

Notes on Coelenterates and Echinoderms From Laguna Beach

The following notes relate to specimens obtained by various students and others in the general region of Laguna Beach during the past year. We have Prof. H. B. Torrey to thank for the general determinations of the first three, the first two from specimens, the third from a photograph. We also wish to thank A. L. Barrows for the verification of certain necessary literature references. All the photographs but one are by Robbins:

Velella septentrionalis Eschscholtz.

Large numbers of these came in during the winter of 1914. Miss P. E. Jahraus preserved a number of fine specimens for the laboratory. They kept their colors in formalin for mone than a year. (Figs. 3 and 7.)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Stylatula gracilis Verrill.

A number of these slender specimens were collected from the shallow waters of Balboa Bay, where they were quite abundant. (Fig. 5.)

Metridium dianthus Ellis.

A fine specimen of this species was brought in by a fisherman from about a 500-foot depth. The fish-hook had caught on its side and the animal did not live many days. It was attached to a chunk of rock with some coral skeletons. This rock fragment to which it clung weighed about ten pounds. Photograph 1-5 natural size. (Fig. 1.)

Bunodactis xanthogrammica Brandt.

These common anemones are abundant on almost every bit of rocky shore. They differ greatly in size and coloration. Many of

those inshore and often uncovered at low tide have bits of rock or shell fragments clinging to them, apparently for protection against crabs and possibly other enemies. These smaller inshore specimens

are usually of a light-brown color. Larger individuals are found in the deeper tide pools, where they are always covered with water. These, as a rule, do not have stones attached to them. The common shore crabs often retreat under the outspread tentacles of these

large individuals. The colors and markings of these are quite variable. Sometimes individuals have a decided blue tinge. Some are quite green. Below Aliso Canyon a beautiful deep-green specimen was found, which was nearly a foot in diameter. Photograph by Miss Clency. (Fig. 6.)

Renilla amesthystina Verrill.

Many specimens of this beautiful sea pansy were dredged just offshore from Emerald Bay. Other specimens were obtained at other places within a mile or more. These were very satisfactory specimens for the aquarium. (Fig. 2.)

Of the two following echinoderms, the first is very common, the other we have not taken before.

Dendraster excentricus Eschscholtz.

Large numbers of these were dredged off Emerald Bay and other places not for from Laguna Beach. (Fig. 4.)

Fig. 8.

Ludia foliata Grube.

A single specimen of this species was dredged by Prof. A. M. Bean off the coast of Laguna Beach. (Fig. 8.)

W. A. Hilton.

(Contribution from the Zoological Laboratory of Pomona College)

An Interesting Basket Star From Laguna Beach

The specimen here recorded was obtained by a fisherman off the coast of Laguna Beach at a depth of nearly a thousand feet. It was sent to Dr. H. L. Clark for determination and the following notes about it are quoted from his letter. The photograph here shown is very much reduced from the original.

Basket Star from Laguna Beach. (Much reduced)

"It is a remarkable example of *Gorgonocephalus eucnemis* (M. and T.), not previously recorded from south of San Francisco, although it may be well known to Pacific coast collectors.

"It is *not* the form of *eucnemis* described by Lyman from San Francisco as *G. caryi* but is a typical example of *G. japonicus* de-

scribed by Döderlein from Tokyo Bay. My opinion (previously published) that *caryi* and *japonicus* are synonyms is thus strongly confirmed.

"It is the largest ophiuran, by far, hitherto recorded. Its disc is about 130 mm. across. The largest specimen I have seen hitherto is 115 mm. Döderlein, in his monograph, has 110 mm. as his maximum measurement."

W. A. Hilton.

Some Remarks on the Central Nervous System of the Starfish

WILLIAM A. HILTON

There are several questions in connection with the central nervous system of star fish which, so far as I know, are not answered by older or more recent investigations. They are as follows:

1. Is there any special center in the radial or circum-oral nervous system?
2. If there are true nerve cells how are they related?
3. Are there true neurofibrillæ?
4. Is there any tigroid substance?
5. Is there any connection between the superficial and the deep radial systems?
6. Are all the elements in the central nervous system nerve cells?
7. Do different species differ from each other materially?

Six species of starfish were collected at Laguna Beach. Two methods were used for fixation; hot mercuric cloride or Flemming's fluid were used upon the whole animal. The first reagent was especially useful in extending the animals and whitening the radial and circum-oral nerves. Borax carmine was used with good results in staining after the first fixation and iron hematoxylin after the second. By both methods cells and fibers were clearly shown.

In all the specimens examined just after killing, the central portion of the radial or circum-oral nerves seemed like a definite line of nervous tissue. Sections showed in some cases a thicker epithelium in the mid-ventral line of the nerves. The radial nerve was often less thick than the central part of the nerve ring. The chief structural difference between the radial and circum-oral nerves in their central portions was in the arrangement of the cells and fibers. In these regions the nerve fibers seem to cross more and run in towards the middle line. This was *very* marked in some specimens. Some indication of this is given by Cuenot, 1890.

In the central nervous system there are unipolar and bipolar cells with long slender processes reaching through the whole thickness of

the nerve band. These fibers are for the most part unbranched except at the inner ends where most seem to be slightly forked just at the inner limit of the nerve band. There may be small branches to a limited degree along the sides of the nerve fibers, but it is very difficult to be sure that this is the case. Certain cells which may be multipolar did not seem true nerve cells. The terminal ends of the nerve cells on the inner side of the nerve band seems to be the chief, if not the only region of interrelation of the nerve cells. I did not find them quite so long or so numerous as Meyer, 1906. There are diagonal fibers, especially in the mid-ventral line of older and larger specimens. There are also a few fibers near the cell-body layer of the nerve strands, which are perpendicular to the other fibers. Very few bipolar cells were found except in the outer zone of nuclei, but there were a few.

The nerve fibers were not found to contain fibrillæ. Possibly each cell has but one fibril. Although the nerve processes differ in diameter none of them seem made of smaller elements. Often several processes from several cells run almost in a single bundle.

The cell-body just about the nucleus was often difficult to make out, although in some cases it retained its epithelial character at the outer end. No clear indications of tigroid substance could be determined.

The two deeper nerves in each arm are not so well marked as the superficial. They are much simpler in structure and not so clearly nervous structures although a few fibers are shown. At the margins of the nerve ring and the other surface nerve bands, there seems to be some connection between the superficial and deep systems, by direct junction in part and by individual fibers in small number passing from the outer to the inner nerve bands.

Most of the cells of the superficial central system seem to be nerve cells, the nuclei of the external zone seem to belong to unipolar or bipolar cells, but a few of these may not be. Between the fibers there is a granular mass which does not clearly show cells, yet there are some cells in it, some dimly shown larger ones and some marked smaller ones which have many fine branches. These smaller cells especially seem like neuroglia cells of other forms.

The following species of starfish were studied: *Linckia columbiæ* (Gray), *Orthasterias gonolena* (Verrill), *Pisaster capitatus* (Stimp.), *P. ochraceus* (Brandt), *Astropecten erinaceus* (Gray), *Asterina miniata* (Brandt). Except for size and difference due to body form, the nervous structures in these species were much alike.

BIBLIOGRAPHY

Cuenot, L. 1890
Le systeme nerveux enterocoelien des echinoderns. Comp. rend. tcxi.

Hamann, O. 1883
Beitrage zur Histologie der Echinodermen. 1. Die Holothurien u. das Nervensystem der Asteriden. Zeit. Wiss. zool. bd. xxxix.

———— 1885
2. Die Asteriden Anat, u. Hist. untersucht. Jena.

Jickeli, C. F. 1888
Vorlaufige Mitt. ueber das nervensystem der Asteriden. Zool. Anz. bd. xi.

Meyer, R. 1906
Untersuchungen ueber den feineren Bau des Nervensystems der Asteriden. (*Asterias rubens.*) Zeit. Wiss. zool. bd. lxxxi.

Owsjannikow, Ph. 1871
Ueber das nervensystem der Seesterne. Bull. de l' acad. imp. des sc., de St. Petersburg. txv.

Wilson, H. 1860
The nervous system of the Asteridæ. Linn. Soc. London, Vol. xxii.

(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF FIGURES

Fig. 1. Cross section of the circum oral nerve of *Asterina miniata*. X55.

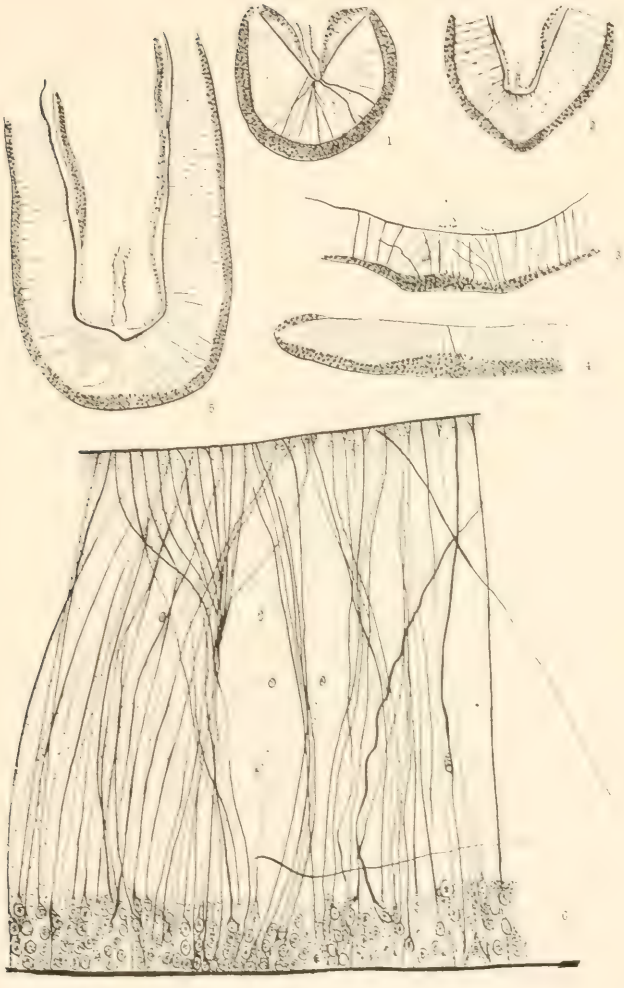
Fig. 2. Cross section of the radial nerve of *Linckia columbiæ*. X55.

Fig. 3. Cross section of the radial nerve of *Pisaster ochraceus*. X55.

Fig. 4. Cross section of the radial nerve of *Astropecten crinaceus*. X55.

Fig. 5. Cross section of a very large specimen of *P. ochraceus*. X55.

Fig. 6. A portion of the middle line of a cross section of the radial nerve of a large specimen of *P. ochraceus*. X800.



Additional List of Annelids From Laguna Beach

W. F. HAMILTON

The following is a list of annelid worms determined from the collections of the summer of 1915. A number of others as yet undetermined may be added later.

Eurythæ californica Johnson

Found crawling along the under sides of stones at low tide.

Halosydna pulchra Johnson

Commensal on the holothurian *Stichopus californicus* (Stimpson).

Phyllodoce medipapillata Moore

Common in kelp holdfast from deep water.

Nereis vexillosa Grube

Found partly digested in the stomach of a baracuda, also on a holdfast.

Lumbrinereis erecta Moore

Abundant in the roots of *Phyllospadix.*

Aracoda semimaculata Moore

Very common under mussels on a flat near the laboratory.

Nainereis longa Moore

Common in *Phyllospadix.*

Nainereis robusta

Found in *Phyllospadix* roots, but not so commonly as the last species.

Sabellaria cementarium Moore

A single specimen was found in a holdfast.

(Contribution from the Zoological Laboratory of Pomona College)

On Two New Polynoids From Laguna

W. F. Hamilton

Halosydna succiniseta, n. sp.

Form attentuated posteriorly, like *H. lordi,* which form this closely resembles. Greatest width about somite 12, whence it tapers gradually to the slender hind end.

Proboscis (Fig. 3) large and strong. It is 4 mm. long and 2.7 mm. wide, cylindroid and slightly flattened distally. Papillæ, 9/9, irregularly conical. Jaws of clear yellowish chitin with large, sharp fangs of dark brown chitin, the lower biting to the right. There is a prominent tubercle, .5 mm., from the ends of each series of papillæ, and an irregular fold of cuticle surrounding the proboscis near the middle.

The prostomium (Fig. 3), decidedly wider than long, is full and rounded, either cheek being almost spherical. Eyes four, the anterior pair are a little larger than, and twice as far apart as the posterior. The tentacle, inserted about one-third the length of the basal segment into the front edge of the prostomium, is slightly longer than the prostomium is wide. Basal segments of the antennæ are produced from the lateral lobes of the prostomium, but cut off from them by a well marked suture. They are nearly as long as the tentacle and all three are produced into long filamentous tips. Palpi, thick, fleshy, tapered, finely papillose and ringed near the tip with dark brown. Tips produced to a hair-like point.

First parapodium achaetous and directed forward at the side of the prostomium. Ventral cirrus conforming to the dorsal type.

Second parapodium with both dorsal and ventral setæ. Notopodium slender, with few dorsal setæ growing out half way between the base and the tip. Neuropodium fleshy, bilobed and long. Ventral cirrus like that on the first foot.

Third parapodium nearly typical. Notopodium half as long as neuropodium, three dorsal setæ, neuropodium thicker and longer, ventral cirrus smaller than on second foot.

Typical parapodium (Fig. 2). Notopodium, achaetous, slender, rounded at tip and about half as long as neuropodium. Acic-

ula, light brown and slightly curved backwards at tip. Notopodium thick, truncate, bi-lobed, five setæ on nearly every foot, arranged directly underneath one another. Neurocirrus short, globose, produced to a fine filamentous tip.

Dorsal setæ (Fig. 1) with notch at tip, serrated on the convex side for a distance equal to twice the width of the spine. As much farther down the concave side is a collar partly surrounding the seta, which then tapers slightly along the shank to the base. These setæ are embedded all but their tips in the flesh of the foot.

Ventral setæ (Fig. 4) are very large, strong and sharp, with a few very minute serrations directly under the hook. The chitin is very light in color and almost perfectly transparent. There is almost no fibrous structure in the core of the spine, and this does not extend to the tip.

Dorsum entirely covered with elytra of a dead gray color, which have a single brown spot just above the elytrophore. The surface is otherwise immaculate. They are non-ciliate, reniform, and born on somites 2, 4, 5, 7, —.

The species is described from an example taken July 9, 1915. The figures were made from an example taken the year before which differs from the typical in having the left eyes fused into one. This anomaly is the first one of its kind I have seen. The pigmentation is scattered in small granules over an area corresponding to that occupied by the eyes on the opposite side.

H. succiniseta belongs to the type of commensal polynoids, but has itself never been found living with another animal.

The chief reason for calling this a new species is the collar on the dorsal seta.

Halosydna lagunæ n. sp.

General aspect like *H. insignis*. Form, oblong-linear, tapering gradually and about equally at both ends. Somites, 26; elytra, 12 pairs on somites 2, 4, 5, 7, —21, 25.

Proboscis (fig. 8), constricted in the middle, bulging at base, and flaring at the end, 5 mm. long and 2.7 mm. wide. Papillæ, blunt, conical, arranged 9/9. Jaws of dark brown chitin, produced into a sharp knife edge. Fangs blunt with three prominent ridges on outside face, lower pair biting to the right.

Prostomium, about as wide as long, slightly constricted at base, widest slightly behind anterior pair of eyes. No fissure behind the insertion of median tentacle. Eyes, four; anterior pair well forward, further apart, and much larger than posterior pair, which are almost under the lip of the peristomium.

Antennæ, dorsal, and peristomal cirri smooth, cylindrical, of moderate length and quite bulbous at tip. Tentacle twice as long as antennæ, and of a similar shape. All tentacles and cirri have dark band just below bulb and another near the middle.

Peristomial parapodia small, achætous, composed principally of the ceratophores. Ventral cirrus conforming to the dorsal type.

Second parapodium with two fascicles of ventral sectæ, differing from the typical in having a longer spinous section. Dorsal ramus very small, equipped with a half dozen minute slender setæ, smooth sharp and straight.

Typical parapodia (fig. 5), distinctly bi-ramous. Neuropodium thickly conical, truncate, fleshy, powerful, wrinkled, carrying two fascicles of ventral setæ. Notopodium thick, short, somewhat rounded at the end, and carrying a flaring bundle of dorsal setæ. Ventral cirrus short, pointed, and subulate.

Setæ of four kinds, short dorsal setæ, slender, straight and serrate (Fig. 10); long dorsal setae, strong, straight, sharp, somewhat hastate, but without the least sign of serrations (Fig. 9); superacicular ventral setæ with about ten spinous serrations, most prominent distally, long hooked point and strong shaft (Fig. 6); sub-acicular ventral setæ, of the same type, but serrations distinctly less prominent (Fig. 7).

Segmental eminences prominent thruout. Nephridial papillæ, cylindrical and fluted, begin on the eighth segment and continue to the twenty-fifth.

Elytra, large, varied in shape from reniform to ovoid. Heavily pigmented with black and brown and have prominent white conical tubercles distributed irregularly over the surface, the larger ones tending to be in the center. Elytra non-ciliate.

Coloration white with brown and black pigmentation on the elytra. Some specimens show a distinct reddish tinge. Dorsally there is a prominent intersegmental black spot. Prostomial and

anal region prevailingly brown, but with some black pigment to be seen.

The specimen is very common under mussels and in sea-weed between tide-marks at Laguna. The type was taken under kelp roots, June 28, 1911, by Prof. C. F. Baker. I have many others in the Laguna collection, among which is a tokous female taken June 27, 1914.

(*Contribution from the Zoological Laboratory of Pomona College.*)

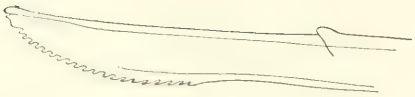
EXPLANATION OF FIGURES.

PLATE I—*Halosydna succiniseta* n. sp.

Figure 1. Dorsal seta.
Figure 2. Typical parapodium.
Figure 3. Anterior end.
Figure 4. Ventral seta.

PLATE II—*Halosydna lagunae* n sp.

Figure 5. Typical parapodium.
Figure 6. Superacicular ventral seta.
Figure 7. Subacicular ventral seta.
Figure 8. Anterior end.
Figure 9. Long dorsal seta.
Figure 10. Short dorsal seta.



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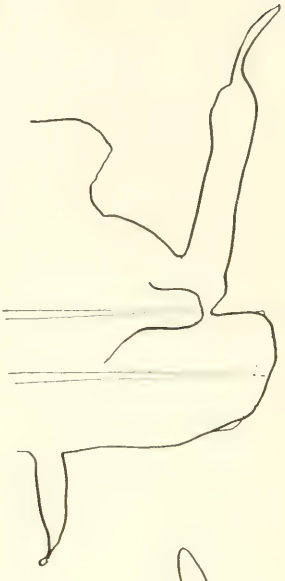

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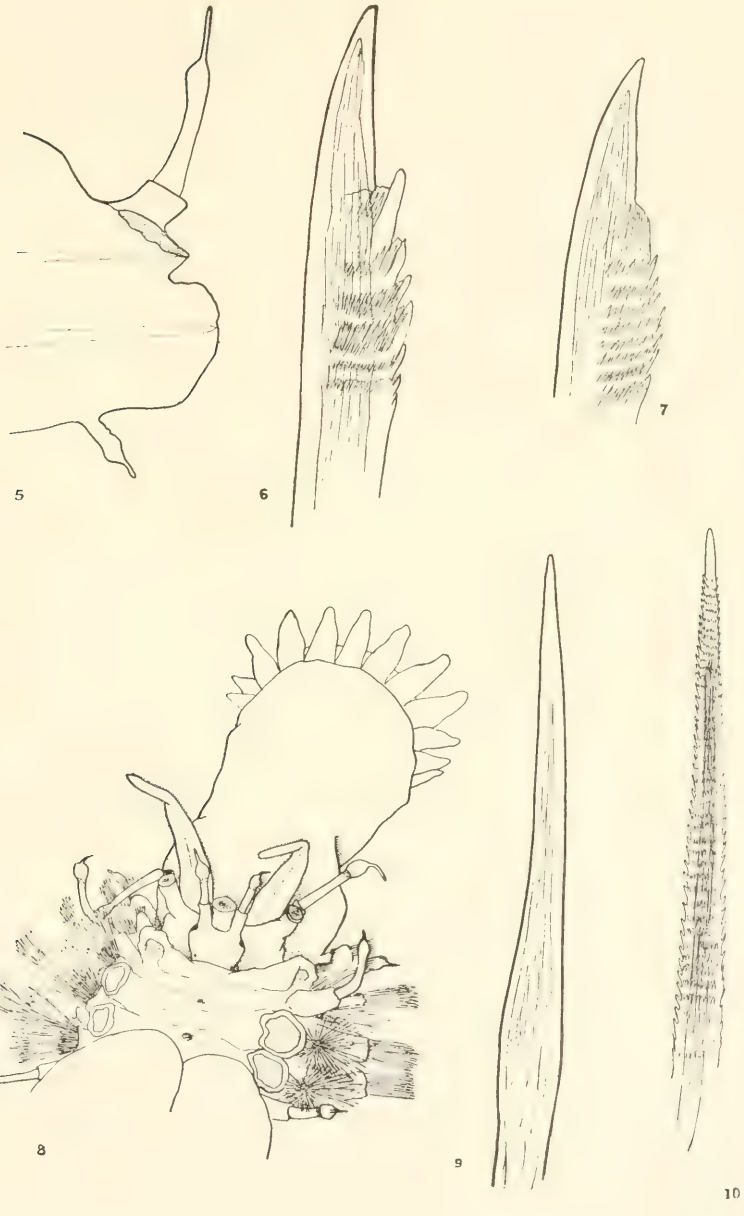
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A Nebalia from Laguna Beach

R. LA FOLLETTE

Among the many marine forms collected and studied at Laguna Beach this summer were several Nebalia, which were taken by Mr. Lichti from a hold fast cast up on the beach. A specimen was sent to the National Museum at Washington, where it was classified as *Nebalia bipes* O. Fab. A brief description of the animal will be given in this paper.

Nebalia bipes O. Fab. (Plate I, Fig. 1) belongs to the order Phyllocarida, which is the linking order between the Branchiopoda and Copepoda on one hand and the Schizopoda and Decapoda on the other. There are only three genera, and the commonest of these is *Nebalia*. So far as I know this form has never before been reported from this region. The specimen here described was 9 mm. in length and a whitish flesh color. It was transparent in the living animal. The body is divided into a head, thorax and abdomen, having the normal malacostracan number of segments, except the abdomen, which is made up of eight, the last bearing caudal styles. There is a bivalved cephalic carapace extending back to the fourth abdominal segment and terminating in front in a movable rostrum. The eyes are large, round and raised on movable stalks.

There are two pairs of antennæ (Plate II, Fig. 2), the first pair being four-jointed, the last joint rather broad and armed with many hairs along the outer margin. The other joints have a few hairs on the articulating margin. The flagellum rises from the fourth joint, behind the fifth and has fourteen joints, each one armed with several hairs on the outer margin of the articulation. The second antennæ are slightly larger than the first and made up of three joints with a brush of plume hairs at the caudal end of the second joint. The flagellum is fourteen jointed. The mandible has a two-jointed palp (Fig. 3), with numerous hairs along the outer margin. The second maxilla also has a palp extending back under the carapace with the function of keeping the carapace free from foreign bodies.

The thoracic feet (Fig. 3) are about 1.5 mm. in length, eight in number and biramous. The outer margins are heavily covered with hair, while the inner margins are comparatively smooth. The first four abdominal appendages (Figs. 5, 6) are much larger than the thoracic feet, being 2.5 mm. in length, and are used for swimming, like those of the copepods. They are also biramous, the back margin and tip having numerous hairs along the edge, while the inner margins are lined with many plumous hairs. The first appendage (Fig. 5) is somewhat heavier than the fourth (Fig 6), but the hairs and spines are arranged in the same relative position. The fifth appendage (Fig. 7) is two-jointed uniramous and small, .9 mm. long. The sixth is one jointed and smaller yet.

The eight abdominal segments taper off in size and the last bears a pair of caudal styles (Fig. 8) which are lined with sharp spines along their outer margins. The ends of the styles are armed with two long, sharp spines.

(Contribution from the Zoological Laboratory of Pomona College.)

EXPLANATION OF PLATE I

MAGNIFICATION 25 TIMES

Figure 1. *Nebalia bipes.*

EXPLANATION OF PLATE II

MAGNIFICATION 25 TIMES

Figure 2. Antennæ.
Figure 3. Mandibular palp.
Figure 4. Thoracic appendage.
Figure 5. First abdominal appendage.
Figure 6. Fourth abdominal appendage.
Figure 7. Fifth abdominal appendage.
Figure 8. Caudal styles.

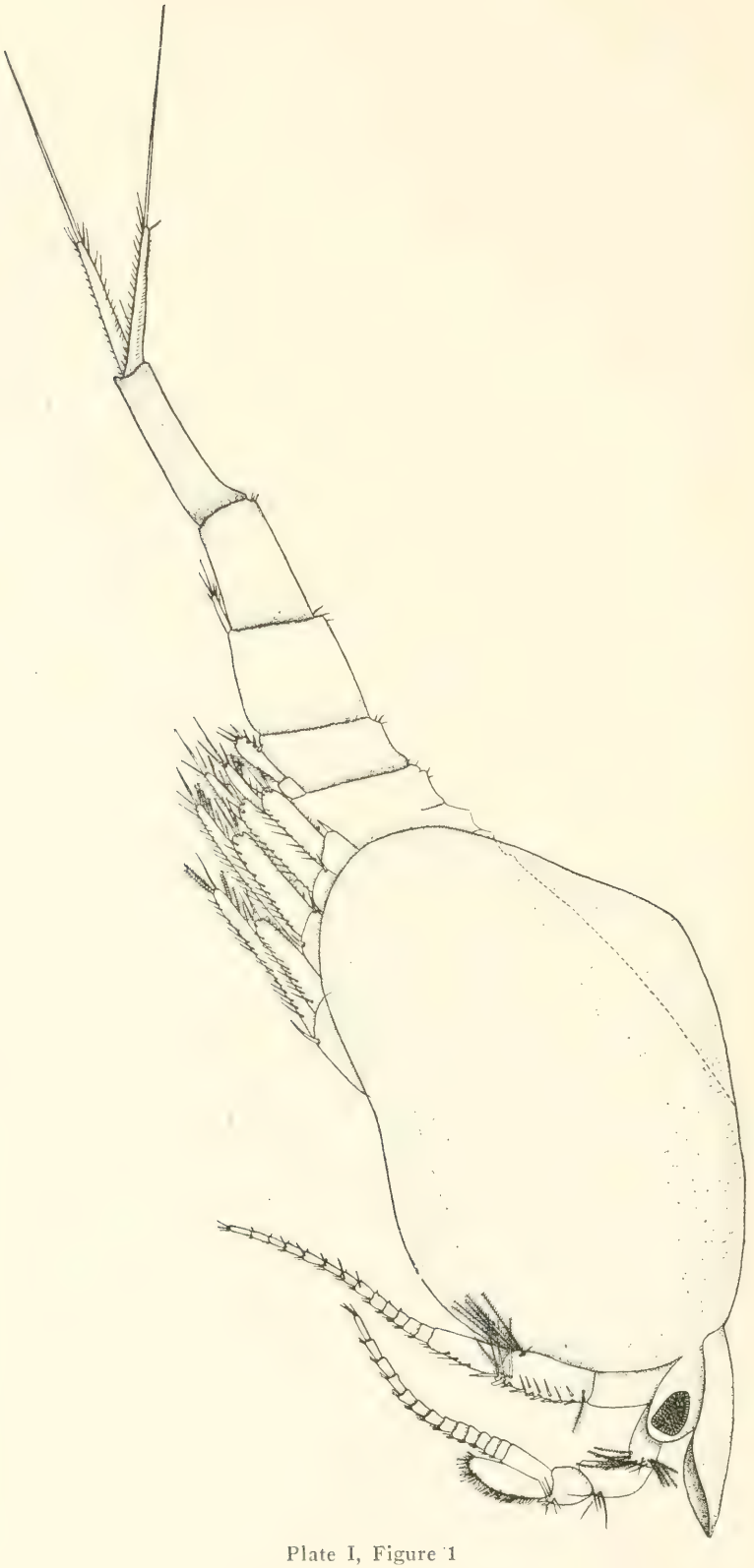
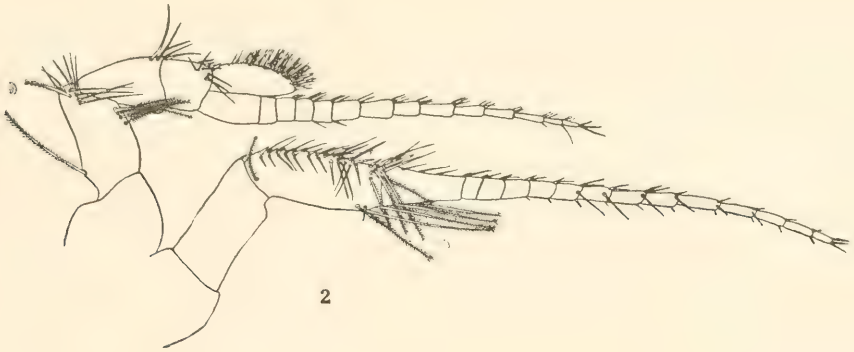


Plate I, Figure 1



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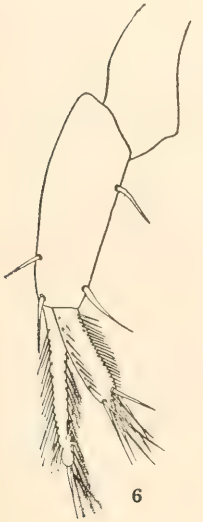

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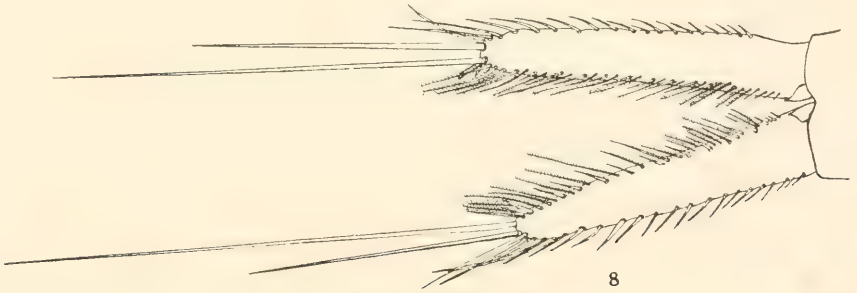

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Plate II

The Early Development of Ligyda with Reference to the Nervous System

William A. Hilton

The material for this study was obtained at Laguna Beach during the summer of 1913. This species of isopod, *Ligyda occidentalis* Dana, is very abundant on the rocks, and it was an easy matter to secure females carrying the eggs or young, and any stage could be easily obtained even late in the summer. With the fresh specimens one of the most valuable methods for preliminary observation was to examine the embryos after fixation, but before dissection or staining or even changing to an alcoholic fluid. The use of Gilson's fluid for this purpose made it possible to detect at once the general features of the embryo even in early stages. This reagent whitened all parts of the embryo and they could be seen as opaque white on the yellowish yolk. Figures 1 to 21 were drawn from embryos treated in this way. The disadvantages of study by this method alone are: First, it is rather hard to tell the meaning of certain parts which show, and, second, cell outlines are not clear except in very early stages. Embryos fixed in this and other ways were removed from the yolk, stained and mounted as a whole, or cut in serial sections.

In the early development of the embryo there is a gradual concentration of cells at one pole of the egg. From Gilson's preparations it was learned that at a very early stage the general area of the optic lobes was outlined, as shown in Figs. 1, 2, 3, and 4. A white spot at the center of the area, later at the caudal end, indicates a thickening of cells which may be in the region of invagination. Gradually thickenings back of the optic area begin to indicate the position of the appendages; two of these are shown in Fig. 3, and a larger number in Figs. 4 and 5. These first thickenings are so faint and so variable in early stages that I cannot place much value upon them. It seems probable, however, that the three marked areas in the cephalic region of Fig. 5, represent the three naupliar appendages recognized by Nusbaum and others. In Fig.

6 the naupliar appendages are better marked and may be considered to be the three large paired areas below the optic lobes. In Figs. 10 and 11, the brain region is outlined; there are also in these stages indications of the various ganglia more or less opposite their appendages. In Fig. 8, many appendages are evident, and there are many more segments than in earlier stages. At this time the segments are similar, the brain and optic lobes show and the mouth area is seen. Fig. 9 shows a typical pair of body ganglia of a slightly earlier stage. At such a stage the ganglia seem made of two pairs. In Fig. 10, the naupliar appendages have changed positions and there is a long series of closely applied appendages similar to those in Fig. 8. Figs. 12 and 13 show considerable shifts in the upper appendages. The lack of harmony between the results of McMurrich and these may be easily explained. The adult isopod has the following appendages: (1) Antennules, (2) antennæ, (3) mandibles, (4) first and second pairs of maxillæ, (5) one pair of maxillipeds, (6) seven thoracic legs, (7) six abdominal appendages. The appendages, as already shown, are first developed in the head region and then added to from the caudal end. At a time of a maximum number of appendages and segments the appendages are much alike, but there are differences in size, and at a later time there are changes in position. In the region of the third and fourth appendages there is a great crowding, so that segments may be fused and appendages covered. This is shown to some degree in Figs. 12, 13, 14, and 15. McMurrich failed to recognize this, and he apparently counted in the first thoracic leg as a maxilliped. The biramous structure of Figs. 12 to 15 is really the first thoracic leg, as is clearly shown in Fig. 13. Other legs of these stages may be seen to be biramous when separated from each other, but this first thoracic leg seems to retain this condition longest and remains small for a long period.

McMurrich failed to call this a leg, and yet had the right number of legs! This probably came about through another slight oversight. At one period preceding Fig. 13 each segment has an appendage, but after a time the last thoracic or first abdominal segment, whichever it is, loses its appendage. This is the segment which seems to have been counted in by McMurrich to bring up the right number of legs.

Each segment of the body has its ganglion at an early time. This segment between thorax and abdomen which loses its appendage has a well developed ganglionic group or mass.

As the optic lobes and brain grow in size, they come to take up a more dorsal position, as seen in the figures. After a time pigment begins to be evident in the lower edge of the eye, as shown in Figs. 22 and 23. When the embryo or young has its eye fully pigmented, the little animal is much like the adult.

The preceding outline of development so far given presents the method of development of the embryo as a whole as well as the gradual increase in size of the ganglia, optic lobes and brain. The development of the cells which take part in this formation of the appendages and nervous system is better shown in whole mounts or sections.

McMurrich, Nusbaum and others show clearly the development of the post-naupliar region of isopods from teloblastic growth. I have very little to add to their complete accounts. Fig. 24 shows a surface view of an unstained egg in which is a half circle of teloblast cells near the center of the early cell area. Fig. 26 shows a later stage of an embryo. The teloblast cells which form the ectoderm are much enlarged and the six middle rows indicate the cells which develop the nervous system. Fig. 25 is from the nervous system of a similar early stage; the lower appendages and the nervous area between are of teloblastic formation, while the cephalic broader portion of the embryo was probably chiefly formed from sells in situ. In Fig. 27 the teloblasts are still adding material at the caudal end of the embryo. Several ganglionic areas are more or less distinct. Sections of stages similar to this show little differentiation between cells of the general surface and the nervous system. In later stages the ectodermal cells multiply to form the ganglia, and the thin line of surface ectoderm becomes separated and splits off.

With the growth of the embryo the cells of the brain and ganglia become marked off from the other cells. A ganglionic area from each of the appendages in the head region is evident, and in addition some cell groups which seem separate, as for instance one near the first antennal ganglion. Into the brain are fused the optic

and first and second antennal ganglia, as well as the more central part of the brain, which is made up of several parts. Into the subesophageal ganglion are fused the lateral parts of the mandibular, two pairs of maxillæ and the pair of maxillipeds. Into the thoracic ganglia there seem to be fused two lateral pairs of ganglia for each segment. In the abdominal region the ganglia are not so clearly made out at all stages. Each ganglion is composed of two lateral halves. There are at one time probably a large number of segments much alike as to their ganglia. The abdominal ganglia become massed closer and closer together and fuse into practically one mass.

McMurrich speaks of an extra appendage without a ganglion in the head region of isopod embryos, about opposite the mandibles. I am not sure but this is the appendage which has been crowded up from below, yet I have found an extra appendage in about this region in certain stages. A number of investigators also speak of an extra ganglion near the brain and separate from the one of the first antenna. I have seen this in a number of stages. It seems like a center of cell growth much like several others.

In Figs. 28, 29, and 31, three different stages in the development of the brain and optic lobes are shown. Whatever the different cell groups may mean, it is possible to trace the development of the areas from one stage to another. Three main parts of each lateral brain and optic lobe region develop quite early. This is due in part to the different directions of cell growth and also to the different rates of growth in different areas. Figs. 30 and 32 are different stages in the development of ganglia viewed from the ventral side. Figs. 31 and 33 are from the same specimen of a rather advanced stage, such a stage as shown in Fig. 14.

The gradual development of the shape of the ganglia, their differentiation from the ectoderm of the surface and the development of the fibrous portions are shown in the drawings of sections of Figs. 33 to 49. The thoracic and abdominal ganglia of a stage such as 11, is shown in cross-section in Figs. 33 and 34. Fig. 35 is a longitudinal section through the ganglion in the middle line of a similar stage. Figs. 48 and 49 are longitudinal and cross-sections through ganglia of stage 13 or 14, ventral side up, areas of

nerve fibers showing clear. Fig. 47 is a section through one side of the optic lobe and brain of the same stage, fiber area clear, cephalic side up. Figs. 36 to 39 are cross sections through ventral ganglia of an embryo 2.5 mm. long, ventral side up. Fig. 40 and Fig. 41 are through one-half of the brain and optic lobes of the last stage; the cephalic side is up. Fig. 42 shows the general arrangement of the brain and head ganglia, as shown in a median longitudinal section, the dorsal side is up. Fig. 43, is a longitudinal section of the abdominal ganglion of a 2.5 mm. embryo; the dorsal side is up. Figs. 44, 45 and 46 are from an embryo of 3.5 mm. length; 45 shows a section of one-half of the brain, cephalic side up, 44 and 46 are sections of the abdominal ganglion, frontal sections, cephalic end up.

At another time it may possible to follow the development of the histological elements of the central nervous system in more detail. What is given now is a mere outline, and does not take up the history of individual cells or cell groups as far as may be possible when the structure of the adult nervous system is carefully studied. In this paper there has been no attempt to follow the developments which do not relate to the central nervous system. A general summary of the development of the brain and ganglia is given as follows:

1. At a very early period the outline of the optic area may be recognized, although the cells which form the brain and optic lobes may not be the ones which give rise to this appearance. Such indications of this area are shown in Figs. 1, 2, 3, and 4.

2. The cephalic portion of the nervous system is then first indicated, the brain and optic lobes and the region of the three naupliar appendages being formed more or less *in situ* from ectodermal cells.

3. The meta-naupliar region of the embryo is formed from regular rows of teloblast cells, such as may first be recognized in a stage like Fig. 24. The ectoderm from these teloblast cells forms the covering for all the lower region of the embryo and along the middle line gives rise to the cells which form the central ganglia, as shown in Fig. 26. At such a period, when the location of the nervous area is possible, six or seven rows of cells in the central region may be considered to cover the nerve ganglion area.

4. The optic lobe and brain area become better and better marked. On each side of the middle line there are three chief areas developed.

5. Ganglia make themselves evident for each of the appendages of the head region below the eyes. There is a crowding together in this region and fusion of the ganglia. The first and second antennæ have their ganglia soon fused with the supra-œsophageal mass. There is in addition to these and the ocular masses an extra ganglionic area which fuses also, but no appendage is evident in connection with it. There are also other centers in the cerebral mass which may simply be centers of cell growth, as indeed this little ganglion may be.

6. The lateral ganglia of the other head appendages fuse into the subœsophageal mass.

7. The ganglia of the body are gradually added to from the teloblastic region at the caudal end of the body. At first the body ganglia are only slightly marked off from the surrounding ectoderm. These early formed ganglia are much alike in early stages, and each has its appendage. At a time of a maximum number of body segments, such as stages a little later than Fig. 8, there is no difference in the ganglia at different segments, except that the more caudal ones are a little smaller and less evident.

8. At an early period the ganglia of all appendages are made up of at least two lateral parts. Some of the ganglia in the thoracic region seem also to be made up of two parts each on each side.

9. When the ganglia are first formed there is little demarcation between them and they are not separate from the skin ectoderm. Later the skin ectoderm forms a distinct layer on the ventral side, as shown in Figs. 33 and 34.

10. In the body ganglia the nerve fibres begin to make themselves evident on the dorsal side as shown in Figs. 48 and 49.

11. In the brain, the fibers from the cells are first evident in central areas, as in Fig. 47.

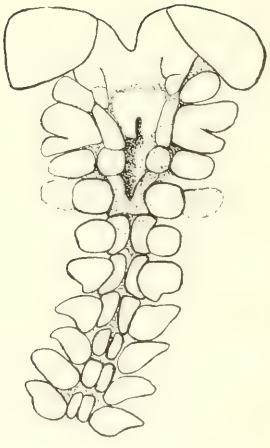
12. The ganglia of the abdominal region become fused into one mass when the young are from 3 to 3½ mm. in length, as shown in Fig. 46.

13. The cells in the body ganglia are not at all periods closely massed. It is possible to determine three main cell masses on each side in certain stages, as well as some smaller unpaired areas, as shown in Fig. 32.

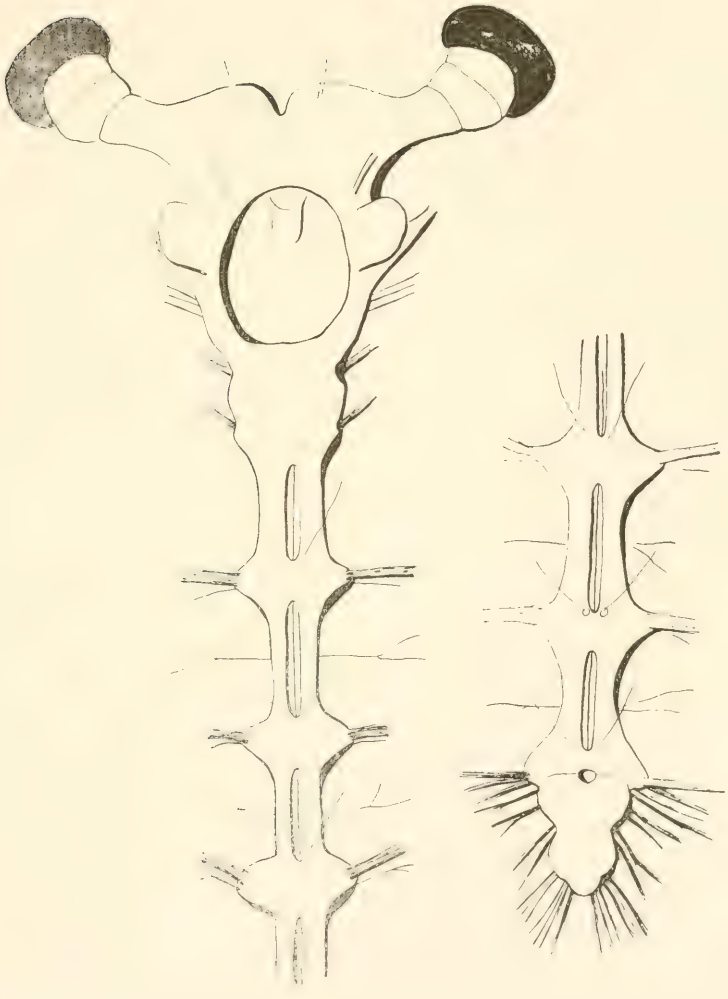
14. In the brain ganglion of an early stage it is possible to distinguish three main areas, counting the optic lobes and the eyes. In the central of these three, on each side there is the ganglion of the first antenna, and in addition four or more other marked areas whose meaning is not yet determined. The more lateral parts of the ganglion and optic lobe area have a large number of centers, as shown in Fig. 31.

15. At first the cells of the brain are much the same size, but in stages when pigment begins to show in the eyes, small cell areas may be found, as in Figs. 40, 41, and 45.

16. At a time when the whole eye of the young is pigmented, the brain and ganglia are much as in the adult, and fiber tracts are evident. It is at such a time that the animal is able to move about and run away; it is now from 3 to 4½ mm. in length.



TEXT FIGURE 1.—Sketch of the head end of an embryo of *Ligyda*, showing the ganglia opposite the appendages. Camera lucida sketch from a mounted preparation. ×70.



TEXT FIGURE 2.—Outline sketch of the central nervous system of *Ligyda*. ×9.

BIBLIOGRAPHY

Brooks, W. K., and Herrick, F. H. 1892
The Embryology and metamorphosis of the Macrura. Proc. nat. acad. sci., Washington.

Bumpus, H. C. 1891
The Embryology of the american lobster. Jour. morph. v.

Dohrn, A. 1867
Die embryonale Entwickelung des Asellus aquaticus. Zeit. f. wiss, Zool. Bd. xvii.

Hewitt, C. G. 1907
Ligia. Liverpool M. B. C., mem. xiv.

Ishikawa, C. 1885
On the development of a fresh-water macrurous crustacean. Quar. jour. mic. sci. xxv.

Kingsley, J. S. 1887
The development of Cragon vulgaris. Bul. Essex inst., xviii.

McMurrich, J. P. 1892
The formation of the germ layers in the isopod Crustacea. Zool. anz. xv.

——— 1895
Embryology of the isopod Crustacea. Jour. morph., vol. xi, No. 1.

Nusbaum, J. 1886
L'embroyologie d'Oniscus murarius. Zool. anz., ix.

——— 1891
Beitrage zur Embryologie der Isopoden. Biol. centralb. xiii.

Reichenbach, H. 1886
Studien zur Entwickelungeschichte des Flusskrebses. Abhandl. Senck. Nat. Geselsch., xiv.

Reinhard, W. 1887
Zur Ontogenie des Porcellio scaber. Zool. anz., x.

(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF FIGURES. DEVELOPMENT OF LIGYDA.

Figures 1-23. Sketches of embryos or parts at various stages. Mostly taken from freshly killed specimens. Figs. 1 to 8, 11-23, ×50; Fig. 9, ×300; Fig. 10, ×100.

Figure 16. Side view of stage like 6 or 7. Fig. 17. Side of 8.

Figure 18 of 11 or 12. Fig. 19 of 13. Fig. 20 of 14. Fig. 21 of 15.

Figure 24. Sketch of an early stage of preserved egg. The cells are indicated as they show on the surface of the yolk. Near the center is a half ring of teloblast cells.

Figure 26. Lower end of an early embryo, showing teloblast cell areas. The six central cell rows are those which go to form the nervous system in part. ×700.

Figure 25. Whole mount of an early embryo. The appendages begin to show. ×70.

Figure 27. Later stage surface mount. ×70.

Figure 28. Surface preparation of one-half the optic lobe and brain region of an embryo such as shown in Fig. 6. The dorsal side is at the top. ×460.

Figure 29. Surface view of one-half of brain and optic lobe region of an embryo like Fig. 8. ×460.

Figure 30. Surface view of body ganglion of embryo like Fig. 8. ×460.

Figure 31. Optic lobes and brain one side, embryo such as Figs. 12 or 13. ×700.

Figure 32. Thoracic ganglion from above, from embryo 12 or 13. ×460.

Figures 33 to 49. Sections of ganglia of various stages. All ×70. Ventral side up in 33 to 39, 48 and 49. Cephalic side up in 40, 41, 44, 45, 46, 47.

Figures 33 and 34. Cross section of body ganglia of 11.

Figure 35. Median longitudinal section of ganglia of 11.

Figures 36 to 39. Cross sections of body ganglia of a 2.5 mm. embryo.

Figures 40 and 41. Sections of one-half brain of a 2.5 mm. embryo.

Figure 42. Longitudinal section cephalic ganglia of a 2.5 mm. embryo.

Figure 43. Longitudinal section abdominal ganglia of a 2.5 mm. embryo.

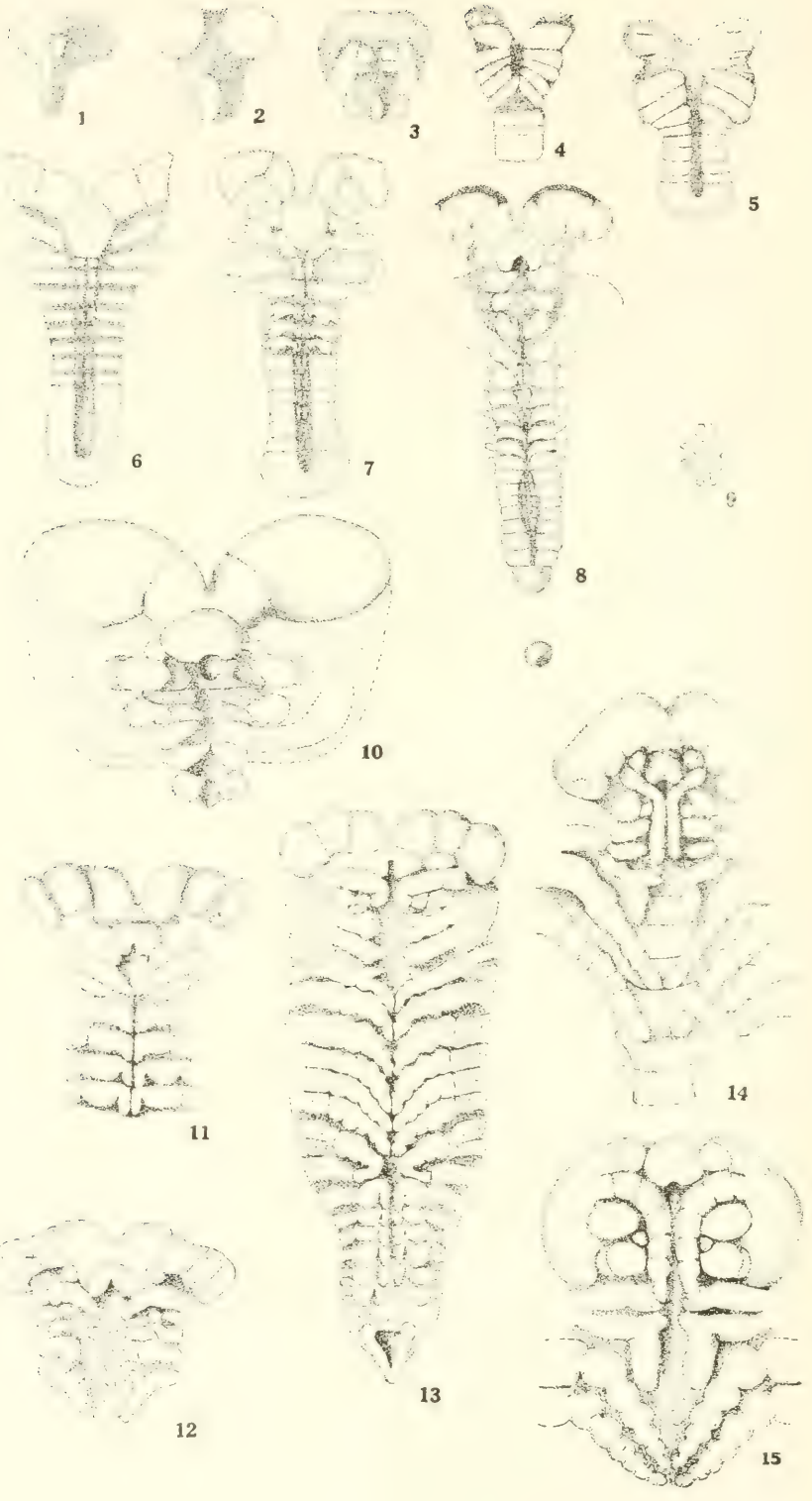
Figures 44 and 46. Longitudinal sections at different levels of the abdominal ganglion of a 3.5 mm. embryo.

Figure 45. Frontal longitudinal section of one-half the brain of a 3.5 mm. embryo.

Figure 47. Section of one-half a brain of an embryo about the stage of Fig. 15.

Figure 48. Longitudinal section of abdominal ganglia of the last.

Figure 49. Cross section, body glanglion of the last.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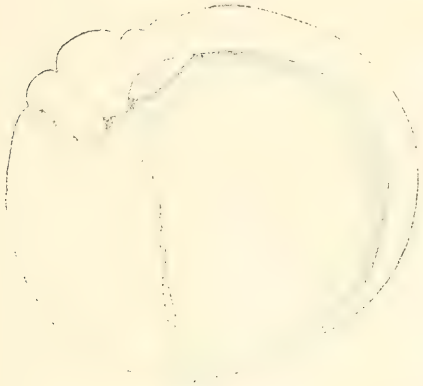

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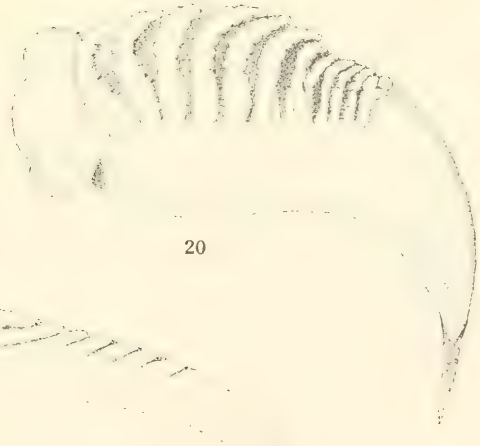

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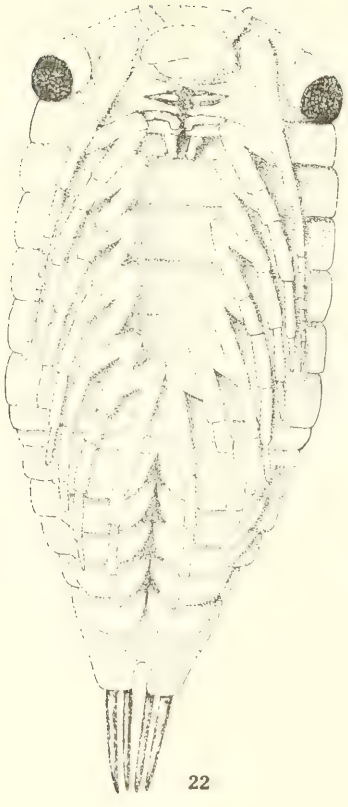

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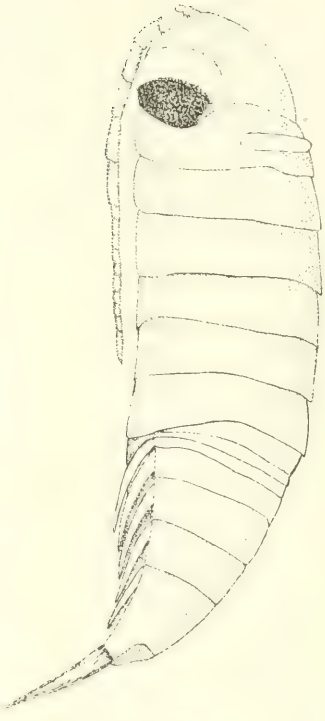

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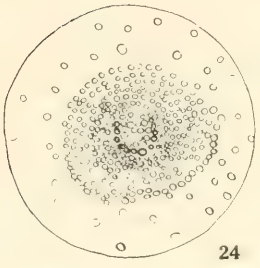

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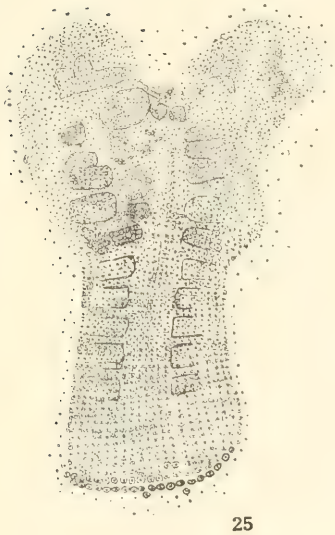

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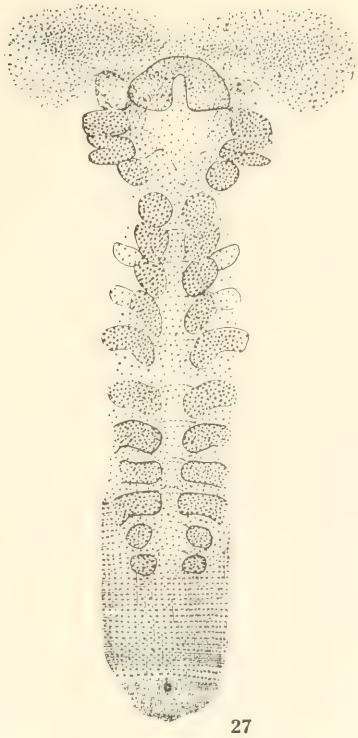

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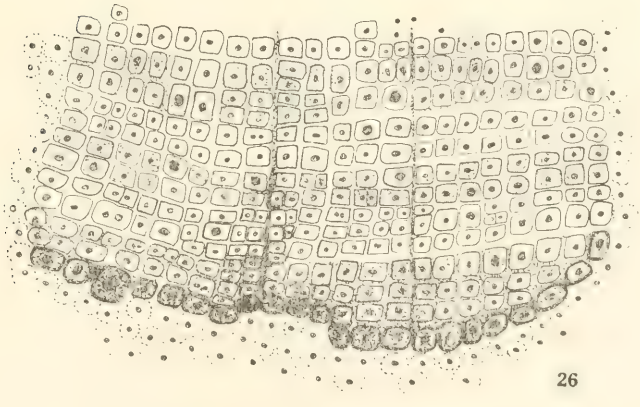

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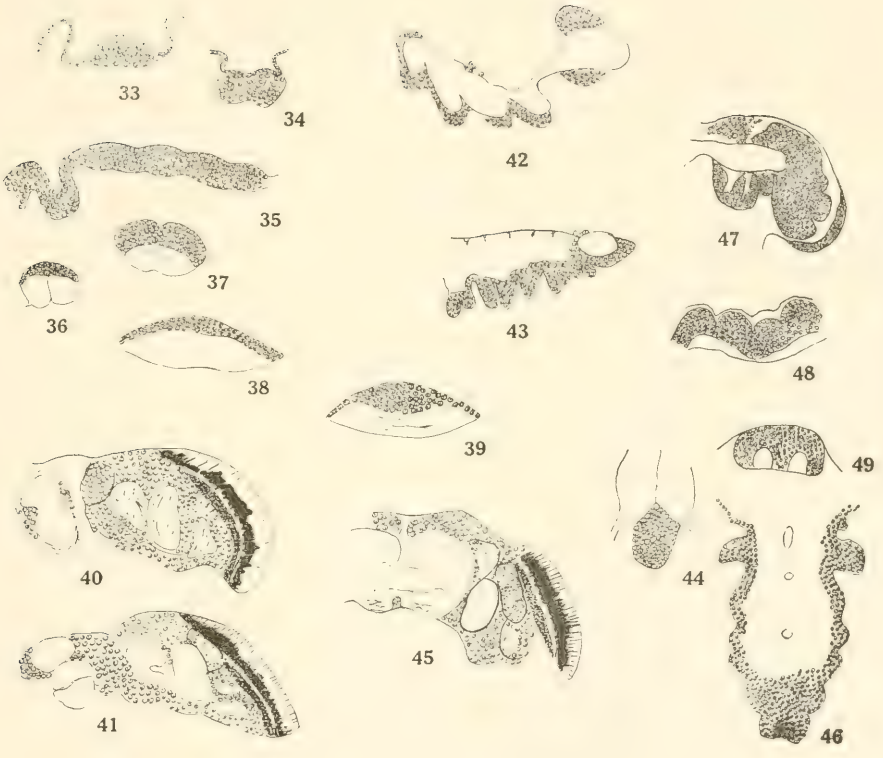
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Crustacea From Laguna Beach

The following notes are on Crustacea collected by general and special students during the past several years. In cases where the forms were especially valuable or rare the name of the collector is indicated. Most of the specimens here recorded were collected during the past two years, a few earlier ones are also included in this report. Those marked U.S.M. were determined for us by the United States National Museum at Washington. The photographs are by Robbins, drawings by Baillard and Macdonald.

Callianassa longimana Stimp.

These "ghost shrimps" are fairly common under stones in tide pools. The median prominence of the front subacute, cornea behind middle of eye stalk. Cheliped of male elongate. Carpus nearly twice as long as broad (Fig. 14).

C. californiensis Dana, U.S.M.

Similar to the other species in general, but the exact distribution of each not yet determined. Specimens of this species were taken at Balboa bay by Mr. Daniels. These showed red in the center of the body and yellow at the sides due to the internal organs showing through. According to Rathbun there are the following differences from the other species: "Median prominence of front rounded; cornea in middle of eye-stalk; large cheliped of male very broad, the carpus very little longer than broad, but longer than palm." Those we have found are smaller than the large of the other species.

Pagurus hirsutiusculus Dana, U.S.M.

This small hermit crab was found in the tide pools. It was collected by La Follette, Macdonald, Hilton and others. Speckled and banded legs.

P. samuelis Stimp., U.S.M.

This small hermit crab was found abundantly in the tide pools. Specimens were larger than the other species as a rule. Blue legs.

Paguristes bakeri Holmes, U.S.M.

This large hermit crab was dredged off the coast of Laguna Beach by Prof. A. M. Bean and W. F. Hamilton. It was found


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living in several of the larger shells such as those of *Trophon triangulatus* Cpr and *T. belcheri* Hds. (Figs. 11 and 12).

Lepidopa myops Stimp.

We have but one specimen of this sand crab collected by L. Gardner several years ago.

Blepharipoda occidentalis Randall

Numbers of these large sand crabs much like the last in general appearance were taken at all times on sandy shores.

Emerita analoga Stimp.

This is the smaller very common sand crab.

Panulirus interruptus Randall

Young of the "lobster" were often found in tide pools.

Alpheus (Cragon) dentipes Guerin

These have been taken in sponge masses and in holdfasts. These interesting little snapping shrimps were collected a number of times especially during the last summer. When placed in aquarium jars they snapped the claws in such a manner as to make one believe the jars were cracking. The left claw open and closed is shown in Fig. 19 from Miss Macdonald's drawing.

Cragon nigromaculatus Sm

Translucent white, with small black dots, a larger dark spot on either side near the caudal end of the body. Found commonly in sandy tide pools.

Betæus longidactylus Lock., U.S.M.

This is the most common lobster-like species found in the tide pools. It is of a uniform dark red brown.

B. harfordi Kingsley, U.S.M.

Found in kelp holdfasts. Pale olive green, eggs translucent green. Stout, Stafford, La Follette and others.

Spirontocaris palpator Osen

Antennal scale longer than the telson, maxilliped without exopod. Rostrum with superior margin not strongly convex, but nearly

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straight over the eyes. Rostrum not reaching the second segment of the antennular peduncle. Rostrum reaching as far as or beyond the cornea. Upper and lower limbs of rostrum not both convex. Almost transparent, red on the thorax. Kelp holdfasts from deep water.

S. picta Stimp., U.S.M.

Antennal peduncle reaching the end of the antennular peduncle. Upper margin of the rostrum straight, reaching beyond the middle of the antennal scale. Greenish with oblique reddish marks.

S. taylori Stimp.

Rostrum not reaching as far as the cornea. Collected several years ago Baker and Metz.

Hippolysmata californica Stimp.

Irregular nearly longitudinal red stripes. These are found quite abundantly in the tide pools.

Palæmonetes hiltoni Schmitt (MSS) U.S.M.

These probably occur off Laguna beach although the specimens described by Schmitt were collected Stout and Stafford at San Pedro.

BRACHYURA

Randallia ornata Randall

These beautiful crabs usually came to us from deeper water, but one was obtained from Balboa bay (Fig. 8).

Epialtus productus Randall, U.S.M.

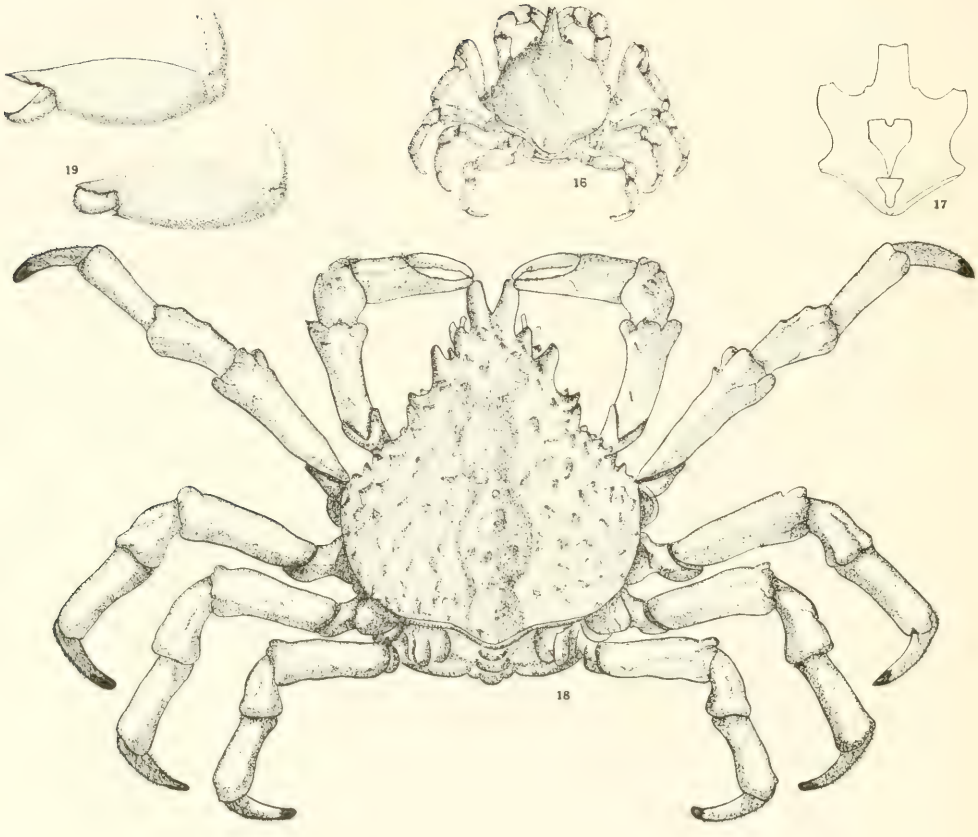
The common kelp crab was found at all times (Fig. 16).

E. nuttallii Randall, U.S.M.

This was the largest kelp crab which we obtained. Fig. 9 is from a smaller specimen than that sent to Washington.

E. bituberculatus Milne Edw. *forma minima* Lockington, U.S.M.

Only one specimen collected at low tide by Hilton. Fig. 17, redrawn from Miss Ballard's color drawing, shows the position of the lighter spots on the dorsal surface.


19
16
17
18

Loxorhynchus grandis Stimp.

A number of these large deep water forms come in every year. Fig. 18 is from Miss Ballard's drawing of a fairly perfect specimen.

L. crispatus Stimp.

One specimen of this moss crab was dredged just off shore by Prof. A. M. Bean and W. F. Hamilton (Fig. 3).

Cycloxanthops novemdentatus Lock, U.S.M.

Fig. 2 of a small one. Fig. 1 larger. These rather large crabs with the dark tipped claws were sometimes taken inshore at low tide.

Cancer antennarius Stimp. Fig 4. U.S.M.

Found under the same conditions as the one just mentioned.

Pilumnus spinohirsutus Lock.

One poorly preserved specimen we took to be this species (Fig. 5).

Heterocrypta occidentalis Dana

Our specimen is from Hermosa Beach. Others have been reported from San Diego. We may yet find it at Laguna (Fig. 7).

Pachygrapsus crassipes Randall

The shore crab is found in great abundance on any rocky shore or in the nearer tide pools (Fig. 10).

Lophopanopeus heathii Rath., U.S.M.

The young of these were often found in masses of Polyzea under rock ledges. A young male was marked as follows: white claws with dark tips, last legs white, other legs and body dark red. A young female had red claws, hind legs white, body darker. Another young male was white.

L. leucomanus Lock.

Adults of these found under stones measured 14 mm. across. Young were found under rock ledges among algæ and polyzoans. Young were found with red claws and a red mouth region.

Dasygyius tuberculatus Lock., U.S.M.

The hydroids on the Balboa piles were swarming with these peculiar spider-like crabs (Fig. 13).

Pachycheles rudis Stimp., U.S.M.

This little crab is found most abundantly in the cavities of the large white sponge.

Petrolisthes eriomerus Stimp., U.S.M.

This is a little flat crab.

P. cinctipes Randall

This has been reported from Laguna by Baker.

P. rathbunæ Schmitt (MSS), U.S.M.

This is the largest flat crab that we have found. One specimen. Hilton, 1913 (Fig. 6 somewhat reduced).

Xanthias taylori Stimp., U.S.M.

This is one of the most common of the crabs found among red sea weeds which it resembles in color and in the little knobs on the anterior parts of the appendages and body.

Herbistia parvifrons Randall, U.S.M.

Moderate sized, narrow headed flat forms. Lateral margin of rostrum not involuted. Second joint of antenna slender subcylindrical. Legs of moderate length.

Pelia clausa Rath., U.S.M.

Found hiding among sponges, polyzoans hydroids and sea weeds. Fragments cling to the animals. A young specimen had blue claws.

Scyra actifrons Dana, U.S.M.

Much as above.

Pugettia richii Dana, U.S.M.

Found much as P. clausa.

P. richii Dana, U.S.M.

Found much as the others just mentioned.

Pelia tumida Lock, U.S.M.

This was the largest decorator which we found.

During the Summer of 1913 a minute elongate crustacean was found by Hilton in Coward's cove near shore.

The U. S. M. determined this to be an immature specimen of Cyathura, of probably a new species. In November of 1915 a larger elongate specimen was secured not far from Balboa. This was also determined to be an immature specimen of the genus Cyathura.

Munidia quadrispina Benedict

A specimen of what was taken to be this species was taken from the stomach of a baracuda caught just off the coast of Laguna Beach (Fig. 15).

W. A. Hilton.

(Contribution from the Zoological Laboratory of Pomona College)

Caprellidæ From Laguna Beach

M. SHAW

Caprella tuberculata n. sp.

The peræon is covered with blunt tubercles, placed in the following positions: Two on the second body segment, one near the center, the other in line with it and posterior. Five on the third segment, one small pair anteriorly situated, another larger pair near the center, one single large one posteriorly situated. Four on the fourth segment: a small pair anteriorly situated, a single large one in center, and a single large one posteriorly situated. Six on the fifth segment: one small pair anteriorly situated, three forming a triangle near the center, and one large one posteriorly situated.

Two fairly large ones on the sixth segment. Also the same on the seventh segment. The peræon has small spines on each side. There are seven tubercles on the ventral side: two on fifth segment, two on the fourth and three on the third.

There are two sharp spines on the first segment: one posteriorly situated, the other on the left, a third of the way down the segment.

The first segment is triangular in shape, shorter than the second. The second and third the same length, the second being broader than the third. The fourth slightly longer than the second and third. The fifth, sixth and seventh each growing smaller, respectively, and truncate at the tip. The branchia ovate in shape. Antennæ stout, superior pair 3 mm. in length. First joint stout and

thick, not as long as second. Third shorter than the first. Flagellum nearly as long as peduncle, having from 10 to 12 joints. Inferior pair of antennæ extending a little past middle of the flagellum of superior.

The first gnathopod attached far forward and small, finger slender, three-fourths as long as hand. One spine near the base of hand, the finger is finely toothed along the inner margin.

The second gnathopod is attached to the middle of the body segment. The basal joint is short and thick. The finger is three-fourths the length of palm and has fine teeth along inner margin. The palm is slightly concave, having one large, sharp tooth at the base, also a small tooth at distal extremity.

Third, fourth, and fifth peræopods similar in structure, armed with stout hairs; palm slightly concave.

Length of specimen, 10-12 mm.

Color, translucent.

Specimens taken at Laguna Beach by Dr. W. A. Hilton, August, 1915, from polyzoa at Abalone Point. Type in Pomona College collection.

Dr. Hilton found another lot of specimens of this genus living among the hydroids at Balboa Bay. It may be a new species, as it differs from any descriptions we have found, but it may simply be a variety of *Caprella geometrica* Say, at least we will not describe it further at this time.

(Contribution from the Zoological Laboratory of Pomona College)

Pycnogonids Collected During the Summer of 1915, at Laguna Beach

WILLIAM A. HILTON

While collecting embryological material from the littoral regions of Laguna Beach, some additional points in connection with the life history, habits and distribution of pycnogonids were brought to light.

In all over seven hundred specimens of various species were found, but a much larger number might have been obtained in certain cases because the localities where they live were so clearly determined.

Certain species were obtained with greater difficulty during the past summer, and some species seemed more abundant. All species found last summer, with the exception of *Phoxichilidium femoratum* Cole and *Nymphon* sp., were found again this year, while three or more species found this summer were not found last. In most cases the pycnogonids were found not far from hydroids, sea anemones or a certain coarse kind of polyzoan. The place which furnished the animals most abundantly was at Balboa Bay among the tubularian hydroids which occur in great masses. In this locality, first brought to my attention by Mr. F. W. Daniels, a hundred pycnogonids were found in one little clump of hydroids, while here and there in other masses they were nearly as abundant. The species found was one not seen last year. It was *Anoplodactylus erectus* Cole. Another species not clearly recognized last year was among *Phyllospadix* in certain localities. Two species found very often in this eel grass were *Ammothella spinosissima* Hall and *Anoplodactylus californicus* Hall. Now and then other forms were collected from these localities, but these two species were found over and over again in certain masses of this plant, especially if hydroids and Polyzoa were near at hand. Under a stone in one situation a large

number of hydroids were found and among and near them quite a number of *A. californicus* were obtained.

Three localities were mentioned last year in the littoral regions: (1) under stones, (2) among coarse polyzoan colonies and (3) out on mussel points among red sea weeds of various sorts. Three other general regions may now be added: (4) among hydroids especially large kinds, (5) among the stems and roots of Phyllospadix, (6) at the bases of sea anemones or near them. In every case except the last, hydroids or polyzoans may be near and aid in determining the occurrence, but in some few cases as under certain large stones, among seaweed and at times in Phyllospadix roots, the polyzoans or hydroids are not evident. The food and shelter of pcynogonids seem in large degree to depend upon these two groups of animals, but pycnogonids probably feed on any soft animal that comes near. Hall mentions one feeding on a nudibranch and I saw a *Palene* devouring a soft annelid worm, its claws and proboscis were stained with its dark juices.

In no case were pycnogonids found in unsheltered situations, they were not found among corallines, nor among certain other seaweeds where the water was swift. Some forms were well inshore, among these was *Ammothella bi-unguiculata* var. *californica* Hall, which was found one day especially abundant under stones well inshore. *A. spinosissima* was always found well inshore, a few under stones but chiefly among Phyllospadix roots. *Anoplodactylus californicus* was found well inshore. *Pycnogonum stearnsi* Ives was also found well inshore. The occurrence of the other species was for the most part farther out than these last mentioned forms.

A few points in connection with the reactions and general habits of these animals might be recorded. I have seen the swimming movements mentioned by Cole especially in *Palene, T. intermedium* to a less degree, as also in *H. viridintestinalis*. The other forms are too heavy to swim or tread water. All the species with long legs move much the same way in walking, alternate legs are moved at the same time as a rule, although now and then adjoining legs may be moved. In those with longer legs, these long appendages

are used as feelers, and one or several of them may be extended or elevated. In a dish of water the animals cannot walk very well, but partly walk and partly swim in some cases. The head end is not always the part which begins or determines the direction of the slow phalangid-like movements. When several specimens are left in a dish it is not long before all are in a ball, holding to each other by means of their sharp claws.

If two specimens are near they are soon drawn together. This clinging instinct is a very important one for the animals and is well developed. Those with long legs if kept separated fold at the third joint so that they look like little stools; they may fold either with the legs on the dorsal or ventral side. Some individuals seem to prefer one side, others fold the legs on either side equally readily. In some, especially those with eggs, the legs are folded in this way over the eggs. In some the legs may be folded closer to the body and the whole animal is like a little ball. In such a form the legs may be made to extend themselves if the animal is lifted and dropped a little distance. This will work every time with some but with a few, such as *A. spinosissima,* the legs become more tightly drawn to the body and the animal may even remain as though dead during several changes of its position. Many, if not most of the Pycnogonids can right themselves if turned over, but most of them rest as well on the back as on the ventral side. Righting movements are either by action of all legs at once from a stool position, or movements of only a few legs. *P. stearnsi* is somewhat an exception to many of the activities of the others mentioned. Its legs do not fold up much, they walk very little, do not swim and are in every way less active than the other species. They do cling to each other and if there are a number in a dish together they soon form a single ball. They cling to each other or to other objects, but from the shape of their legs and bodies they cannot hold very fast to anything.

The following is a list of the specimens obtained during the summer of 1915. At another time some further observations relating to the life history of at least one species may be given.

Palene californiensis Hall

Found almost entirely among the zooids of a certain coarse polyzoan. Seventeen specimens collected.

Lecythorhynchus marginatus Cole

No new information was obtained about this species. Found as last year among mussels, now and then in red seaweeds. They can walk quite rapidly through seaweeds. One hundred specimens were collected.

Ammothella bi-unguiculata var. *californica* Hall

Found among mussels to a limited degree, chiefly under stones at low tide. Fifteen specimens were collected.

Ammothella spinosissima Hall

Last year this species was found under stones only, but this summer most of them were found in the roots of *Phyllospadix*. This species is an inshore form. It is rather slow in its movements and depends upon its form and color to escape observation. The masses of sand caught in the long spines and hairs often help to conceal it. When much disturbed it may fold up and appear to be dead. Seven specimens were found.

Ammothella spinifera Cole

No specimens of this species were found last year. Two were found this summer among mussels out on the points.

Ammothella tuberculata Cole

Found as last year, among mussels and coarse polyzoans. Twenty-seven specimens.

Tanystylum intermedium Cole

A large number of these, one hundred and thirty-one in all, were found chiefly among polyzoan colonies; also under stones and among mussels to a limited degree.

Tanystylum orbiculare Wilson

Many of these, eighty-one in all, were found among mussels and older polyzoan stems.

Clotenia occidentalis Cole

Only one specimen found among mussels.

Halosoma viridintestinalis Cole

A number of these, ten in all, were found as last year among polyzoan masses.

Anoplodactylus californicus Hall

More of these were found than last year, chiefly among the roots of *Phyleospadix*. Those that were found abundantly under stones were near large hydroids. Thirteen specimens in all were collected.

Anoplodactylus erectus Cole

None of these were found last year, while between two and three hundred were found this season. All but one were taken from tubularian hydroids at Balboa. The one specimen from nearer Laguna was from an uncertain location and was a young specimen. The first lot obtained from Mr. Daniels contained a hundred specimens—immature and young adults, but no specimens with eggs. At a later time large numbers with eggs were obtained chiefly from the older stems of the hydroid masses. On the polyps and in them various stages of development were found. At a later time the life history of this species will be considered more in detail.

Pycnogonum stearnsi Ives

Last year only two specimens of this species were obtained. This year twenty-four were collected and many more might have been taken. No males with eggs were found, but in September a number of very young were obtained. Most of the specimens were found at the bases of medium-sized sea anemones; a few were found well inshore in seaweeds near sea anemones. They seem to be fairly abundant in some places. Often one large one was seen first and then under it one or two smaller specimens were found. When a number were placed in a dish they formed themselves into a compact ball. They are slow in their movements, and as they are inshore species it may be that they live better in the

laboratory than other species. The legs are capable of very little movement and they rest for long periods in a stationary position.

In addition to the above there were numerous embryonic and larval stages of various species and a number of immature and undetermined forms. Among the undetermined forms was a most interesting and peculiar adult specimen which may prove to be a new species, or at least quite a different type of pycnogonid. It will be described at a later time.

(Contribution from the Zoological Laboratory of Pomona College)

The Life History of *Anoplodactylus Erectus* Cole

WILLIAM A. HILTON

As an introduction to the statement of the life history of this species it may be worth while to briefly review something of the literature on the subject and follow this with all that is known of our Californian or Laguna Beach forms.

The fact that the males carry the eggs after laying was first determined by Cavanna in 1877. The eggs are large or smaller according to the yolk present. In *Phoxichilidium* and *Tanystylum* studied by Morgan, the eggs are .05 mm., in *Palene*, .25 mm. In certain species of *Nymphon* they have been described as large as .5 to .7 mm. in diamater, Dohrn, '81. The egg masses are one or more for each leg. In *Palene* there are only two eggs in each group, but according to Dohrn there may be a hundred or more in each bunch. In some cases both legs hold a single mass. Segmentation is complete and equal in the smaller eggs, unequal in the larger. The best account of the later development is given by Meisenheimer for *Ammothea* in 1902. A typical gastrula is formed by an ingrowth of cells from the uniform almost solid previous stage. This gastrula however has no cavity, but later it forms into midgut and dorsal and lateral parts, the sources of the heart, muscles and connective tissues. Later there is a longitudinal germ band about the yolk and in this, paired thickenings appear which represent the cerebral and subesophageal ganglia, lateral thickenings mark the point of origin of the appendages. The chelifori are the first to appear. In *Palene* (Morgan) the fourth leg is next, then the fifth and sixth. The third and seventh come just before hatching.

Palene and some other forms such as some species of *Nymphon* have in the larva all of the appendages of the adult, but most free larvæ are provided with three pairs of appendages. Such are called protonymphon stages. In various species these appendages differ somewhat, but in practically all, the body is similar at first. The body during early larval stages is roughly circular in outline, the

first appendages are short, strong and chelate, the other two appendages are more slender and may be moderate in length or very long. All appendages or only one or two may be provided with long spines near the base. Two types of protonymphon stages may be recognized, the most common such as found in species of the genera, *Nymphon, Ammothea, Tanystylum, Zetes* (*Eurycyde*), by Dohrn, Hoek, Morgan, Meisenheimer, Meinert and others.

The genus *Pycnogonum* is in a way an intermediate type for the first appendage bears a long hair-like process, as shown by Hoek, '81, and Meinert, '98.

The genera *Phoxichilidium* and *Anoplodactylus* have long tendril-like extensions from the two body appendages. These larvæ were first noticed by Gegenbauer in 1854, among hydroids, later by Allman '59, in a similar situation. Both of these investigators supposed that the eggs of *Phoxichilidium* were laid in the hydroids. Hodge in 1862 showed that it was the larva which made its way into the cavity of the hydroid polyp. Semper 1874, gives a very good outline of the life history of *P. mutilatum*. Adlerz in 1888 gives more detail in the larval stages of *P. femoratum*. A large number of others have described parasitic habits of pycnogonids besides those already mentioned. Hallez in 1905 speaks of the mutual modifications of larvæ and hydroid, various degrees of parasitism were found in different species. In one case the larvæ were from .1 mm. to .8 mm. in length in different stages, the last stage being somewhat elongate in form. Mertens in '06 found a larva in *Tethys* which he described as a new species of *Nymphon*. Loman '08 was one of the latest to consider this kind of parasitism among pycnogonids. Some earlier writers who also considered this subject were Kroyer '42, Lendenfeld '83, and Strethill '63.

Among the Laguna Beach pycnogonids the eggs were held by the males in from two to sixteen bunches. *Palene* has about two eggs in two clusters. *Halosoma* had from six to eight small bunches. *T. intermedium* had usually about four. *T. orbiculare* from two to four clusters. *L. marginatus,* usually four. *A. spinosissima* about 11 bunches. *A. californicus* sixteen small bunches of many eggs. *A. erectus* sixteen. The eggs differ greatly in size in the different species. The eggs of *Halosoma* are the smallest yet recorded,

.02 mm. *A. erectus* are .03 mm. in diameter, *A. californicus* .035, *A. spinosissima* .0425, *A. bi-unguiculata var. calif.* .0575, *T. intermedium* .06, *A. tuberculata* .0675, *L. marginatus* .065, *Palene californiensis* .175. All measurements were from preserved eggs.

Palene was found to have immature stages much as has been given by Morgan for this genus and Meinert for *Pseudopalene.* The larvæ of *Ammothella, Tanystylum, Clotenia, Lecythorhynchus* so far as determined were not provided with the long hair-like appendages. The other genera not mentioned at this time were not obtained in sufficient numbers to draw any conclusions. *Anoplodactylus* of the two species found were provided with the long appendages in early stages.

On the piles at Balboa bay, great masses of hydroids of several species may be found, the species which is most abundant seems to be *Tubularia crocea* Ag. Living among these hydroids are spider crabs, amphipods and other crustaceans, molluscs, and other hydroids. Among a mass of old tangled stems in a single location a large number of adult males of *A. erectus* was found bearing egg masses in all stages from the egg up to the first larval stage. Figs. 1 and 2 are drawings from such stages. This was in the first week of September, 1915. Earlier in the same year Mr. F. W. Daniels brought me some hydroids that were literally swarming with pycnogonids. These were from the same locality. In these hydroids were found the stages shown in Figs. 3 and 4. These larvæ were very abundant in the digestive cavities of nearly every polyp. In some cases three or four might be found in one place. Swarming over the surface of the hydroids were the more mature stages, some small, others larger but at this particular place none of them mature. Many were such as shown in Fig. 5 with the fourth pair of legs represented by lobes at the caudal end of the body. Judging from the observations made, eggs are produced in summer and early fall; the long-armed first stage larvæ come from the males at various times and as they reach the hydroids the long appendages are lost, probably by a moult and then by two distinct stages such as shown in Figs. 3 and 4, they grow in size, three pairs of legs grow out and they leave the interior of the polyps and live for a time in the immature state clinging to the gonosome or tentacles of the hy-

droids. In the last of November of the same year not a single larva, immature form or adult, was found although a very thorough search was made of the surface and interior of the polyps and dead stems.

Figs. 1, 2 and 3 are drawn to the same scale, X350. In Fig. 6, a number of stages from the egg to the latest larval stage is shown, all drawn at the same scale. Stage *b* probably moults upon entering the polyp; as judged from the cast skins, there is probably a moult between *c* and *a*, and *d* and *e*. As shown in Fig. 3, there are little knobs left just ahead of the limb buds. These knobs are the vestiges of the whip-like appendages of the earlier stage. According to Semper these two appendages degenerate completely, Adlerz believes that some vestiges of these remain and in their place the second and third limbs of the adult are formed. Meinert believes that the second and third appendages of the larva entirely disappear and the palps and ovigers are new structures. I am sure from the examination of many embryos of *A. erectus* that the larval second and third appendages disappear beyond recognition and that the ovigers develop after the animal is almost an adult, but I am not sure that the little knob which may be seen in parasitic and later stages does not represent the ovigers. If this last be true, it would be very difficult to prove that it was an entirely new structure, because it grows out from the place where the third larval organ disappears. The chelifori of the larval stages are continued directly to the adult condition. Very little of the internal structure is shown from the surface of the earliest stages. The nervous system is not shown as a distinct area in earliest larval stages although it is well shown and well developed in the similar stages of other larvæ. It may be that the probable lack of activity may not necessitate the sharp demarkation of the brain and ganglia. Later parasitic larval stages show well-marked ganglia for the larger appendages and smaller ones for the caudal and cephalic ends. At the caudal end there seems to be a gradual development of the ganglia with the development of the caudal end of the animal and in some free living forms there seem to be at least two pairs of ganglia beyond the thoracic or leg ganglia. At the cephalic end it is more difficult to make accurate observations. In parasitic

stages there seem to be from one to two distinct ganglia which may be those of the ovigers and palps. In addition to these there were found from one to two isolated pairs of what were taken to be ganglia in the proboscis.

BIBLIOGRAPHY

Adlerz, G. 1888
Bidrag till pantopodernas Morf. Bihang till k. Sv. Veten. Akad. Hand. Bd. xiii Afd. iv., No. 11.

Allman 1859
Symnoblastic Hydroids. Rep. Brit. Ass.

Cavanna, G. 1877
Studi e ricerche sui Picnogonidi. Pub. r. inst. di super. prat. e. di. perfez. in Frienze. Sez. di scienze fis. e. natur. p. 3-18.

Dohrn, A. 1870
Untersuchungen uber Bau und Entwicklung der Arthropoden. 2. Pycnogoniden. Jen. Zeitsch. f. Nat. Bd. v.
Die Pantopoden des Golfes von Neapel. Fauna u Flora Golfes Neapel. Monog. iii. 1881

———

Gegenbauer, C. 1854
Zur Lehre vom Generationswechsel.

Hallez, P. 1905
Observations sur le parasitisme des larves de Phoxichilidium chez Bouganvilla. Arch. zool. exp. et gen. 4me serie t. iii.

Hoek, P. P. C. 1881
Nouvelles etudes sur les pycnogonides. Arch. zool. exp. et. gen. t. ix.

Hodge, G. 1862
Observations on a species of Pycnogon (P. coccineum) with an attempt to explain the order of its development. Ann. mag. nat. hist. (3) vol. ix.

Kroyer, H. 1842
Notes sur les metamorphoses des pycnogonides. Ann. sc. nat. 2e ser. t. xvii.

Lendenfeld, R. von 1883
Die Larvenentwicklung von Phoxichilidium plumularie. Zeit. Wiss. Zool. Bd. xxxviii.

Loman 1908

Die Pantopoda der Siboga Exp.

Meisenheimer, J. 1902

Beitrage zur Entwicklungsgeschichte der Pantopoden, I Die Entw. von Ammothea echinata Hodge bis zur Ausbildung der Larvenform. Zeit. f. Wiss. Zool. lxxii Bd.

Mertens, H. 1906

Eine auf Tethys leporina parasitisch lebende Pantopoden larva (Nymphon parasitica n. sp.). Mitt. aus. der Zoo. Stat. Neapel, xviii.

Meinert, Fr. 1898

Pycnogonida. Den Danske Ingolf-Expedition.

Morgan, T. H. 1891

A contribution to the embryology and phylogeny of pycnogonids. Stud. biol. lab. Johns Hopkins Univ. Vol. v.

Semper, C. 1874

Ueber Pycnogoniden und ihre in Hydroiden schmarotzenden Larvenformen. Arb. Zool. Inst. Univ. Wurzburg. Bd. i.

Strethill, W. 1863

On the development of Pycnogon larvæ within the polyps of Hydractinia achinata. Jour. Mic. sc. vol. iii., p. 51.

(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF FIGURES

Figure 1. Embryo of *A. erectus* Cole X350. The embryo was taken from the female.

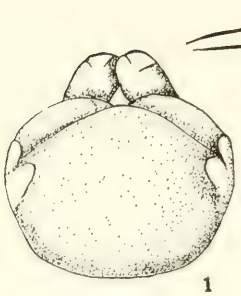
Figure 2. Larva of *A. erectus* Cole X350. Just hatched larva with appendages straightened.

Figure 3. Larva taken from the digestive tube of the hydroid. X350.

Figure 4. Much later larva of *A. erectus* taken from the digestive tube of a hydroid. This is much less enlarged than the last. X75.

Figure 5. Free living immature specimen of *A. erectus,* taken from the surface of a mass of hydroids. X35.

Figure 6. Outline of stages in the early life history of *A. erectus.* All figures drawn to the same scale X50. (a) Egg, (b) just hatched larva, (c, d, e and f) parasitic stages all found at the same time in two polyps.



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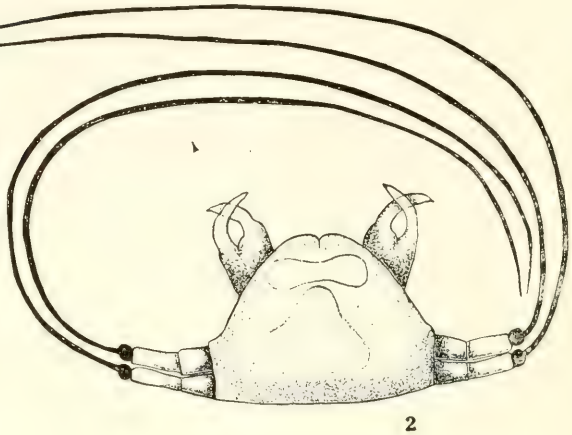

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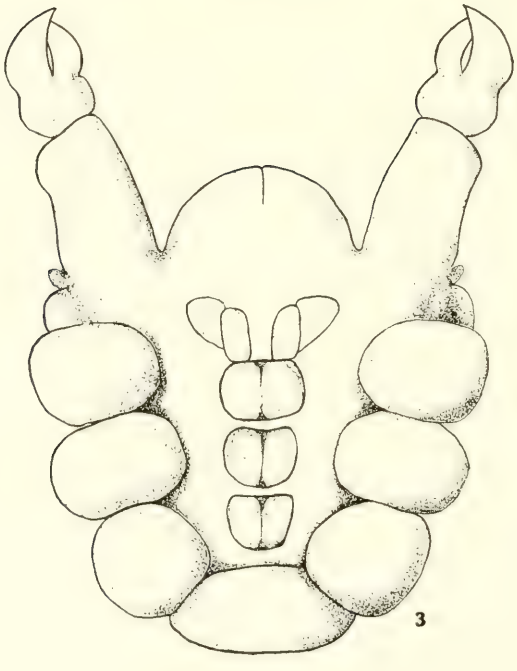

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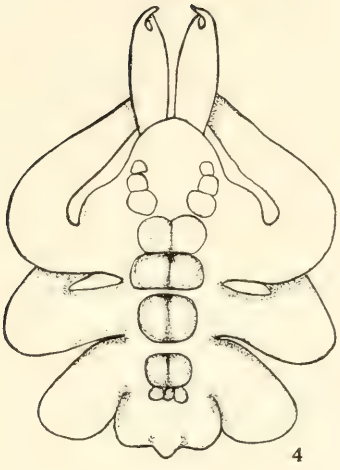

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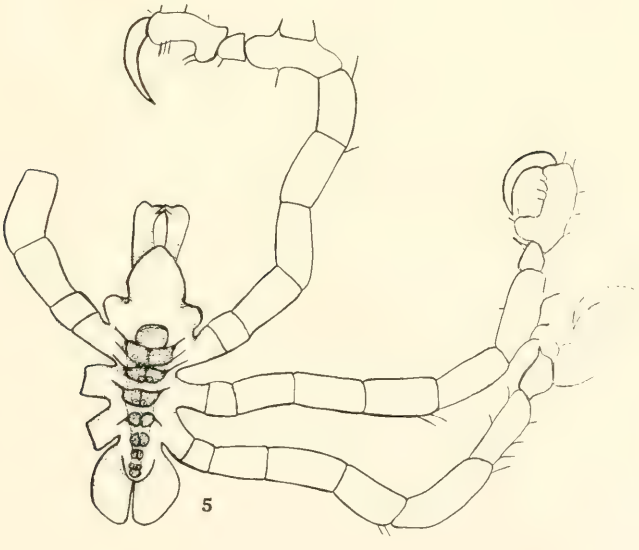

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6

A Remarkable Pycnogonid

William A. Hilton

In a collection of a thousand pycnogonids obtained at Laguna Beach and nearby a single specimen of the species here described was found. This was taken near Laguna under a stone at low tide. The two-jointed proboscis, the segmented body, the long tapering legs with their peculiar spines and hairs, these and other features were distinctive.

After searching through the rather extensive literature of this group it was found that few species resembled this one. Epecially was the proboscis different. The genus *Ascorhynchus* established by Sars in 1876 seems very close to it, but there are a number of slight differences. No species in this genus is like it. The genus *Eurycyde,* Schodte, 1857, as described by Sars in his great work of 1891 seems to fit this specimen exactly. The species *E. hispada* Kroyer, as described and figured by Sars seems at first to be nearly the same as the specimen at hand, but a careful examination shows numerous specific differences. Sars considers this *E. hispada* the only species of the genus described at that time, 1891. I have found no species of this genus described since. *E. hispada* Kr. has been found on the coast of Greenland, Finmark, Nordland, in the Kara sea; at a depth of 50 to 191 fathoms.

Eurycyde spinosa n. sp.

Type specimen—a female in the collection of Pomona College. Total length 3.085 mm. Extent from side to side 3.6 mm. (obtained from a preserved specimen mounted on a slide). Collected at low tide under a rock, Two Rock Bay, Laguna Beach, California, September, 1915.

Trunk rather broad. Lateral processes long, swollen caudally. Segments of trunk plainly marked from each other. Chitin thick. Caudal segment long slender. It projects upwards at a moderate angle and bears four large hairs or spines near the end, two of these are central, two are more lateral.

The eye tubercle just in front of the ovigers, projects nearly straight up in the unmounted specimen. It bears four eyes and is pointed. One large hair and several smaller ones project from it.

The proboscis is two-jointed, the basal joint is narrower and cylindrical. The terminal joint is swollen in the middle and tapers at the tip, and tapers a little less at the base. The proboscis is bent at the base of the terminal joint and the tip points backwards under the animal.

In the freshly killed animal the legs and all the leg-like appendages were easily seen from above, but in the slide the ovigers did not show from above nor do they in the figure.

The chelifori are three-jointed, the terminal joint is small, slightly lobed but not chelate. The other segments are of nearly the same length but the basal one is thicker. There are a number of long spine-like hairs on the middle joint and one large one on the basal joint.

The palpi are ten-jointed, the two basal joints small, the five terminal joints are also small and bear fine hairs.

The ovigers are nine, possibly ten, jointed, rather larger than the first two appendages and quite a little longer than the body. In the fresh specimen this appendage looks much like a leg from above. There are two claws, the terminal larger. The terminal joints bear a number of complicated spines and knobs as shown in the figure.

The legs are broad at the body and taper towards the claws. The basal joint is provided with a single large spine. The narrower second joint bears two spines. The third joint is smaller and bears no spines. The fourth joint is usually about twice the length of the last and bears five spines at the end. The fifth joint bears several spines on the shaft as shown in the figure. The sixth joint is about as long as the fifth and bears spines on the shaft as shown in the figure of the four legs. The last two joints bear only a few smaller hairs. There is one slightly hooked claw on each leg.

The wide lateral processes of the body, the first angular joint of the legs, the complicated spines of the oviger and the different arrangement of spines on appendages and body clearly separate this species from the other members of the genus.

WORKS CHIEFLY CONSULTED

Carpenter, G. H. 1905
The marine fauna of the coast of Ireland. Pycnogonida. Fisheries, Ireland, Sci. inves. IV.

———— 1893
On some Pycnogonida from the Irish coasts. Sci. proc. R. Dublin soc. vol. viii.

Cole, L. J. 1914
Pycnogonida from the west coast of North America. Harriman Alaska Expid.

Hoek, P. P. C. 1877
Ueber Pycnogoniden. Niederl. Arch. f. zool. Bd. 3 Taf. XV-XVI.

———— 1881
Report on the Pycnogonida. Zool. of the Challenger. pt. x.

———— 1881
Nouvelles etudes sur les pycnogonides. Arc. d. zool. exper. et gen. vol. ix.

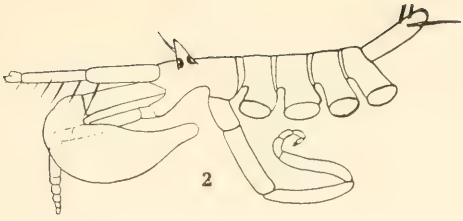
Meinert, Fr. 1898
Pycnogonida. Den Danske ingolf-expedition.

Sars, G. O. 1891
Pycnogonida. Den Norske Nordhavs exped. 1876-78.

Wilson, E. 1878
The Pycnogonida of New England and adjacent waters. Rep. U. S. com. fish and fisheries, pt. vi.

(Contribution from the Zoological Laboratory of Pomona College)

Figure 1. *Eurycyde spinosa* n. sp. from above. Drawn by means of projectoscope from mounted specimen. X25.
Figure 2. *Eurycyde spinosa* n. sp. from the side, legs not shown. Less magnification than fig. 1.
Figure 3. Right chelifor, not all of basal joint shown. X75.
Figure 4. Right palpus. X75.
Figure 5. Oviger from the right side. X75.
Figure 6. Tip of first leg, from the right side. X75.



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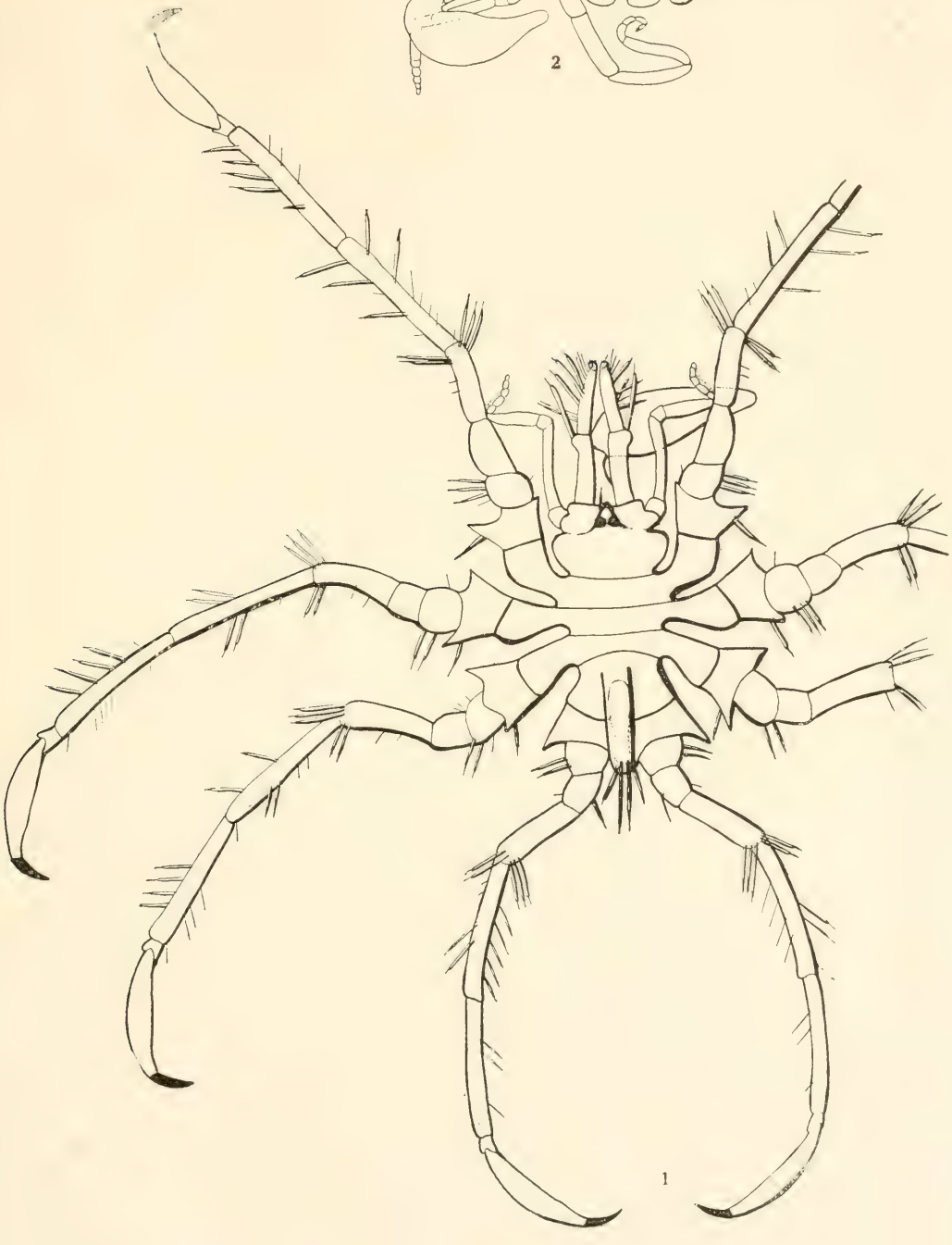

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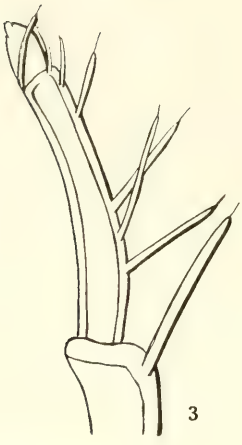

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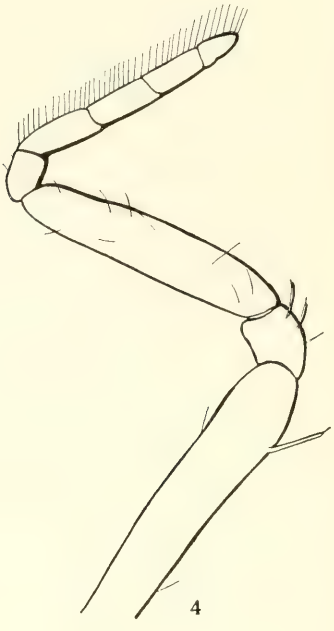

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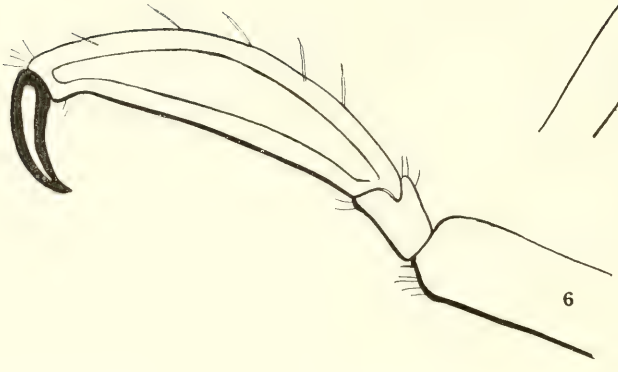

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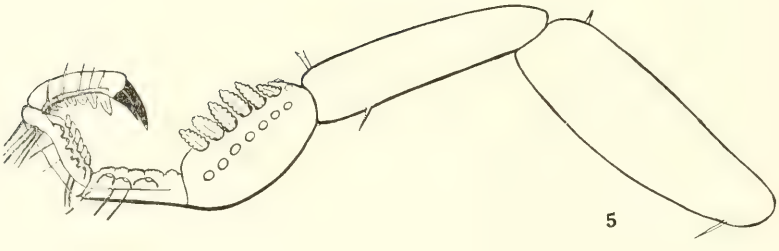

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October, 1916

THE NERVOUS SYSTEM OF PYCNOGONIDS

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Zoölogical Laboratory of Pomona College, Claremont, Cal.

TWENTY-ONE FIGURES

The nervous system of pycnogonids presents many peculiarities. It is rather difficult to find the counterpart of this system in other arthropods. The nervous system of some Crustacea suggests it, especially in those forms with an elongated thoracic region and reduced abdomen. The general arrangement of the ganglia is totally unlike the central nervous system of arachnids although the general form of the body of 'sea spiders' strongly suggests arachnid relationships. The rather small supraesophageal ganglion and the well developed chain of ventral ganglia suggest a rather primitive type of nervous system, but the innervation of the pharynx and proboscis presents complex and apparently unique conditions.

Although there is an extensive literature on the classification, structure and development of pycnogonids, there is little or nothing on the structure of the nervous system.

The general form of the ganglia with their chief branches is quite well known, for nearly every paper on the classification of the group contains a more or less detailed sketch of the animals described with the nervous system shown in place.

The supraesophageal ganglion seems to contain but two pairs of ganglia recognized by early authors in other arthropods as the protocerebrum and deutocerebrum, the tritocerebrum found in some arthropods being absent. This is but one of several structures that point to a closer relationship with arachnids than with Crustacea. However, without going into further reasons at this time, I am inclined to side with Dohrn and consider Pycnogonida a separate class.

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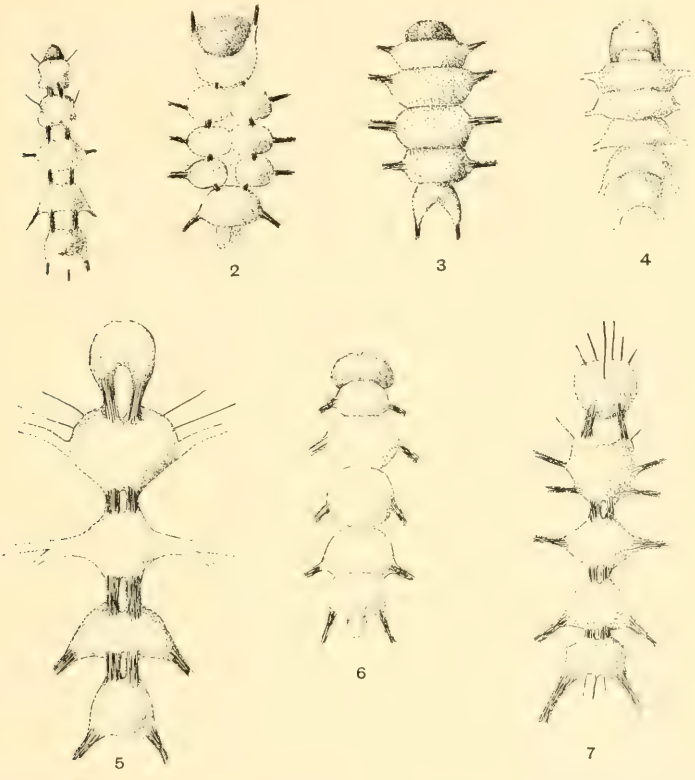
As the tendency has been to regard these animals as arachnids, it may be worth while to glance through the neurological literature on this group.

Among the earliest work on the nervous system of arachnids was that of Treviranus in 1812. No hint of pycnogonids is given in this paper, nor is there any mention of these animals in the work of B. Haller just a century later. There is no reference to pycnogonids in the extensive work of Saint Remy, '90. Dahl, in 1913, gives a brief summary of the work of Dohrn in connection with various types of arachnids. If we go through the extensive literature on the pycnogonids as a group we find, it is true, little of the structure of the nervous system, but much about the arrangement of the ganglia composing it.

From the works of Hoek, '78, '81, Dohrn '70, '81, Sars '91, Meinert '98, and a number of others, as well as from the study of Pacific coast forms, we learn that the central nervous system consists of a supraesophageal ganglion and a ventral chain of from four to five chief ganglia. The smaller number of ganglia we find when the body is less elongate. The supraesophageal ganglion has a ventral median nerve to the proboscis, nerves to the eyes and a pair to the chelifori. Each ventral ganglion has at least one main branch. Three branches from the first ventral ganglion are as follows: 1) A small pair or two pairs to the proboscis; 2) a pair to the palps; 3) a pair to the ovigers; 4) if the first ganglion is fused with the second as it is in those with four ganglia, then there is also a pair to the first pair of walking legs.

Figures 1 to 7 show different types of nervous systems from Pacific species of pycnogonids. The method by which the nervous system was studied by some observers was simply to determine the position of the ganglia through the transparent body-wall. This was tried with a number of specimens after the animals had been fixed in mercuric fluids. In some cases the whole animal was stained and mounted in such a way as to show the internal ganglia. In some cases the animals to be studied were placed for a short time in caustic or acid and by one or the other of these methods the internal parts were

cleared so that the ganglia might be seen. Serial sections of the whole animals were also made for study, but the chitin often makes perfect series impossible. Hoek and possibly



Figs. 1 to 7 Drawings from the adult nervous systems of a number of species of California pycnogonids. The supraesophageal ganglion is shown at the upper end of the figures in every case. The nerves are not all shown in every figure. All are shown from the ventral side, the ganglia were exposed by various methods and all are not drawn to quite the same scale.

Fig. 1 Eurycyde spinosa, Hilton.
Fig. 2 Halosoma viridintestinalis, Cole.
Fig. 3 Tantystylum intermedium, Cole.
Fig. 4 Ammothella tubercuata, Cole.
Fig. 5 Pycnogonium stearnsi, Ives.
Fig. 6 Palene californiensis, Hall.
Fig. 7 Anophlodactylus erectus, Cole.

some others have used gross dissection with the larger species. I also tried this method and found that it was not difficult to expose and remove the whole nervous system from even the smallest specimens. For the structure of the ganglia serial sections were made from these removed ganglia.

There seems to be some difference of opinion as to number and position of abdominal ganglia. There are without doubt ganglia in the adult that may be called abdominal, but they are often not evident or indicated by slight knobs on the last ganglion. Probably in no case are these little ganglia in the abdomen (figs. 1, 2, 6, 7, 19).

The special nerve supply to the proboscis has been described by Hoek, Dohrn and others. I was able to dissect it out in a number of species where I have found essentially the same features already described. In the genus Pycnogonum I found a similar condition as shown by Hoek. Practically the same condition was found in two other genera not before described. There are three main branches which run to the three divisions of the proboscis: a dorsal branch running from the mid-ventral line of the supraesophageal ganglion, and two lateral branches springing from the forward part of the first ventral ganglion. Each of these branches has numerous small ganglia along its course and near the end of each branch there is a much larger ganglion. Branches connect the three trunks with each other and fine nerves run from each ganglion to adjacent parts of the proboscis. Lateral to these three ganglionated branches is a more external nerve which sometimes has a separate origin from the larger ganglia or from the ganglionated trunks. These three more superficial branches appear to fuse in places with the deeper branches, but they do not bear ganglia.

This whole complicated structure seems quite unusual and some have seen in this proboscis region the representations of other segments of the animals. However I prefer the assumption of Dohrn that the proboscis represents only a secondary growth of the lips of the stomodoeum. I believe the special nerves of the proboscis represent the system of frontal nerves and ganglia which we find in Insecta and other arthropods.

The small ganglia of the proboscis are rather new structures, but the large, represent the frontal and lateral head ganglia of other forms.

The development of the nervous system of pycnogonids has been especially studied by Morgan, '91, and Meisenheimer, '03, although a number of others have studied the general life histories, or special stages. According to Meisenheimer, in the embryos of Ammothea the early development of the ganglia is much as in other arthropods, a longitudinal strip or germ band enwraps the yolk and paired thickenings of the ectoderm occur which represent cerebral and post-oral ganglia. I have not followed these earliest stages in any of my material. At the time that the free larva is liberated, there is seen a supraesophageal ganglion and three pairs of sub-intestinal centers such as shown in figure 13 of a California form of the same genus. The second of these two ganglia is composed of two parts and represents the second and third parts fused. This type of larval nervous system seems rather typical of this sort of larval form. What the changes are from this to the adult are not exactly known, but suggestions may be obtained from the study of other species. Morgan in Tanystylum gives some idea of the gradual development of additional ganglia in the caudal region as the larva with three pairs of appendages add a fourth and a fifth pair successively and later a sixth pair. At this last period the maximum number of ganglia is attained, this number becomes reduced with the growth of the seventh pair of appendages and the adult condition is reached. During the early stages the addition of extra ganglia is probably not so much from the backward growth of nervous tissue as from later developments from the surface. In Palene the type of development is different because of the large yolk mass. Separate ganglia for the segments are developed, each of these has at an early period an invagination or 'ventral organ.'

The species whose development I have especially studied seems intermediate between the free living larval form and such a continuous type of development as shown by Palene. This genus Anophlodactylus is more parasitic during larval stages

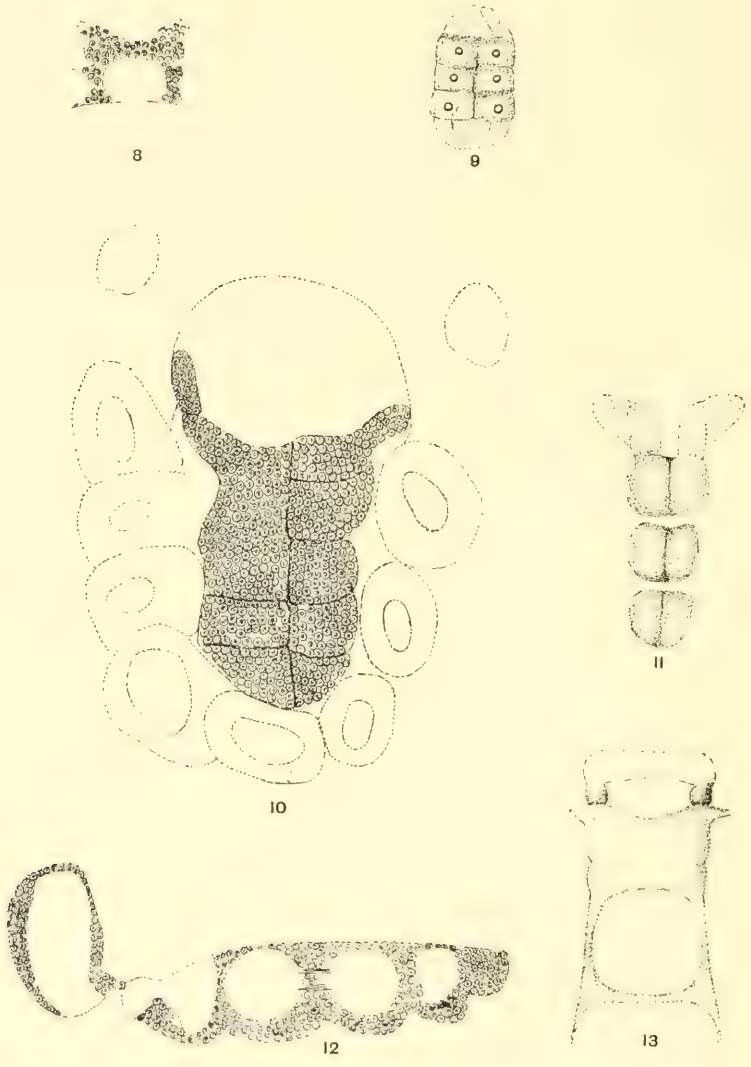


Fig. 8 Central nervous system of A. erectus during first larval stage. × 350.

Fig. 9 Nervous system of A. erectus during the second larval period. × 350.

Fig. 10 Section through whole larva of A. erectus during the third larval period. × 350.

Fig. 11 Central nervous system of A. erectus at about the third larval stage. Drawn from a whole mount which did not show as much as some others. × 300.

Fig. 12 Longitudinal section through the central nervous system of A. erectus during the last larval stage. × 350.

Fig. 13 The central nervous system of the first larval stage of Ammothella. × 350.

than the others mentioned. The first larval stage soon attaches itself to, and enters hydroids. It has three appendages in the first larval stage, one pair is chelate, the last two have long tendril-like extensions. At such a period the nervous system is not easily made out from surface views, but it is much like that of Ammothella. Figure 8 shows three parts, a larger thicker portion which has nerves to the larger first appendages, and on each side back of this a group of cells corresponding to the other appendages. A moult within the hydroid gives rise to a small larval form without the long appendages and it is at

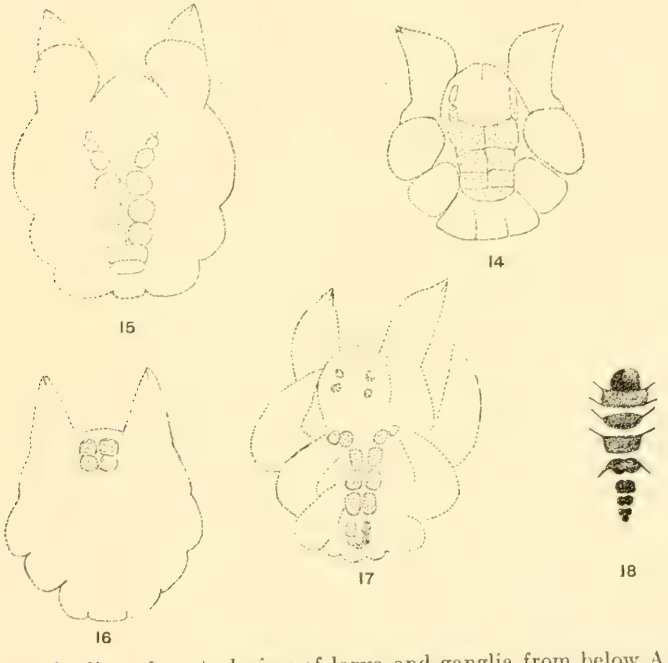


Fig. 14 Outline of ventral view of larva and ganglia from below A. erectus, third larval stage. × 85.

Fig. 15 Outline of a ventral view of a later stage larva than figure 14 of A. erectus. × 85.

Fig. 16 Outline of a dorsal view of a larva of A. erectus about the same stage as figure 14. The brain is shown. × 85.

Fig. 17 Fourth stage larva of A. erectus from below. × 35.

Fig. 18 Central ganglia of a larva of A. erectus with three pairs of walking legs. The drawing is from below. The upper area without nerves in the figure is the supraesophageal ganglion. × 35.

such a period that new ganglionic material seems to be developed. Figures 9, 11 and 14 are drawn from such early stages. At a later moult more ganglia are evident, as in figures 10, 15, and 16. The ventral ganglia at first are mere groups of cells, as is shown in the frontal section from which figure 10 was taken. As may be seen from the figures 10 and 15, ganglia are developed in each segment, a pair for each appendage and several for the cephalic region and a common mass of cells for the ab-

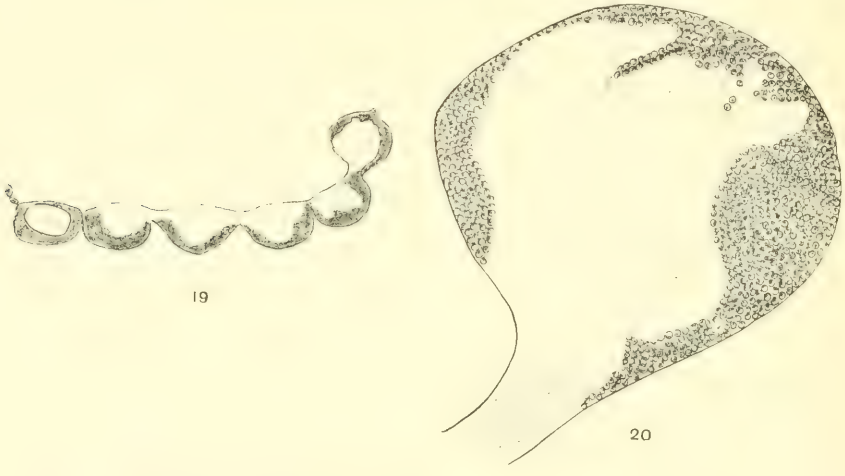


Fig. 19 A longitudinal section through the central ganglia of Lecythorhynchus marginatus, Cole. Two small abdominal ganglia show at the end of the last thoracic ganglion. × 35.

Fig. 20 A longitudinal section through the supraesophageal ganglion of L. marginatus. The dorsal side is up, the cephalic side to the right. × 210.

dominal. In a stage just before this there are two pairs of ganglia on the dorsal side of the larva; these are shown in figure 16. They represent the brain.

At about the third moult, as shown in figures 12 and 17, the ganglia have developed central fibers, but still show their paired nature. There seems to be some indication of more ganglia than there are appendages, some of the caudal elements may not be evident in later stages, and the first ventral ganglion seems composed of two small pairs of elements. In the proboscis

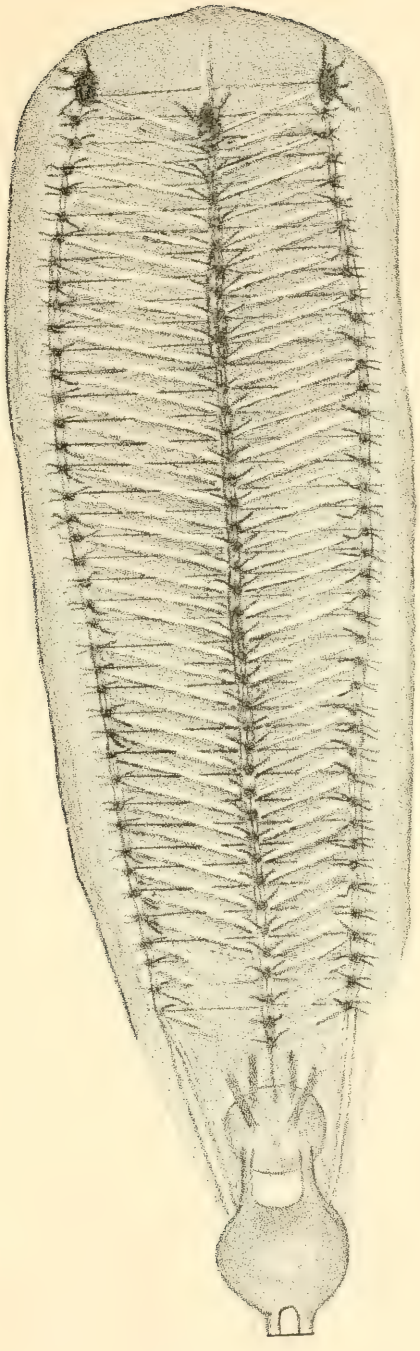


Fig. 21. Drawing of the nerves and ganglia of the proboscis of L. marginatus. Slightly diagrammatic. No structures shown in the proboscis but nerves and ganglia. The drawing was made by Miss M. L. Moles from the first sketch taken from the dissection. Much enlarged.

of this stage there seem to be two small pairs of ganglia. The dorsal ganglia are not shown in figure 17.

When the larvae moult again and leave the cavity of the hydroids they have all but one pair of legs. Figure 18 shows the whole central nervous system from below at such a stage. The brain above the esophagus is at the upper end of the figure, then follow the ventral ganglia, seven paired masses and a small unpaired caudal ganglion. There is a gradual fusion of these ganglia until the adult condition shown in figure 7 is attained.

The structure of the adult nervous system of pycnogonids is quite simple. There is the same general arrangement of cells that we find in other arthropods. The ventral ganglia have few cells on the dorsal side, but many on the lateral and ventral sides. The supraesophageal ganglion is sheathed in cells on the lateral and dorsal sides. Nerve fibers connect the ganglia and certain regions but in no place is there a concentration of the fibers. The fibrous mass is not particularly dense at any point. There do not seem to be many long tracts and the supraesophageal ganglion is not more complicated than other parts so far as could be determined. There are no marked decussations of nerve fibers and the nerve cells present a uniform appearance. Among the nerve cells are many nuclei of neuroglia networks which form the framework of the ganglia especially in the area of the cells.

Although there are indications of special groups of cells and fibers, there was no indications of mushroom bodies.

The animals do not seem to have a special brain. The supraesophageal ganglion is not a very special center. The movements of the animals agree with this; they move sideways, forwards or backwards when stimulated. No part of the body seems to lead in the locomotion.

BIBLIOGRAPHY

Alderz, G. 1888 Bidrag till Pantopodernas Morphologi och Utvecklings historia. Bihang till k. Svenska Vetenskap Akad. Hand., Bd. 13, afd 4, no 11, Stockholm.

Dahl, F. 1913 Vergleich. Phys. und Morph. der Spinnentiere, Erster Teil, Jena.

Dohrn, A. 1870 Untersuch. über Bau und Entw. der Arthropoden. 2. Pycnogoniden. Jen. Zeit. f. Nat., Bd. 5.

1881 Die Pantopoden des Golfes von Neapel. Fauna und Flora des Golfes von Neapel. Monog. 3, Leipzig.

Haller, B. 1912 Über das Zentralnervensystem des Scorpions und der Spinnen. Arch. f. Micr. Anat., Bd. 79, Abt. 1.

Hallez, P. 1905 Observations sue le parasitisme des larves de Phoxichilidium chez Bouganvilla. Arch. zool. exp. et gen., 4me serie, t. 3.

Hilton, W. A. 1916 The life-history of Anoplodactylus erectus Cole. Jour. ent. and zool., vol. 8, no 1, March.

Hoek, P. P. C. 1881 Report on the pycnogonida. Voyage of H. M. S. Challenger, Zoology, vol. 3.

1881 Nouvelles études sur les pycnogonids. Arch. Zool. exp., t. 9, Paris.

Hodge, G. 1862 Observations on a species of pycnogon (Phoxichilidium coccineum) with an attempt to explain the order of its development. Ann. mag. nat. hist. (3), vol. 9.

Kroyer, H. 1842 Notes sur les metamorphoses des pycnogonides. Ann. sc. nat. 2e ser., t. 17.

Lendenfeld, R. von 1883 Die Larvenentwicklung von Phoxichilidium plumularie. Zeit. Wiss. Zool., Bd. 38.

Meisenheimer, J. 1902 Beitrage zur Entwick. der Pantopoden. Zeit. f. Wiss. Zool., Bd. 72.

Mertens, H. 1906 Eine auf Tethys leporina, parasitisch lebende Pantopoden larva (Nymphon parasitica n. sp.). Mitt. aus der Zool. Stat. Neapel, Bd. 18.

Meinert, Fr. 1898 Pycnogonida den Daniske Ingolf-expedition.

Morgan, T. H. 1891 Contribution to the embryology and phylogeny of pycnogonids. Stud. biol. lab. Johns Hopkins Univ., vol. 5.

New Californian Mites

Nathan Banks

The following new specias form part of an interesting collection of mites recently sent by Dr. Hilton for determination:

Trombidium perscabrum n. sp.

Red. Body about one and one-half times as long as broad, subpyriform, broadest at humeri, broadly rounded behind. Cephalothorax very short, with crista reaching almost to the hind margin and there enlarged, and with a long fine hair arising from each sensilla. Eyes near lateral margin on a very short elevation. Body clothed with short, capitate hairs with roughened tips, some near the eyes are longer than the others. Among these capitate hairs are tufts of shorter spine-like hairs. Legs also clothed with similar, but mostly more clavate than capitate hairs, roughened on sides and end; some of the apical joints beneath have more slender hairs, and tarsus I. has them only on the base above, elsewhere with long, fine hairs. Leg IV. is about as long as the body, the last joint as long as the penultimate; leg I. plainly shorter than the body, tarsus I. fusiform, longer than the penultimate joint and about twice as broad. Palpi rather stout, basal joints with clavate hairs above, below with simple or pectinate hairs, and similar hairs on the fourth joint. Thumb as long as third and fourth joints together, cylindrical, rather longer than the claw.

Length, 1.4 mm.

From Claremont, California, January.

Differs from *T. scabrum* in having the clavate hairs on legs and palpi, and in the cylindrical thumb.

Erythræus posticatus n. sp.

Body dark (probably red in life), legs pale. Body about one and two-thirds times as long as broad, broadly rounded behind, as broad at hind coxa as at humeri; cephalothorax narrowed in front, crista short, swollen at hind end, one eye spot each side. Body and legs clothed with simple hairs, not very densely, and about as long

as width of basal joints of legs; tarsus I. with shorter hairs, those below very short and dense. Leg I. about as long as body, tibia and metatarsus subequal, tarsus nearly two-thirds as long as metatarsus, and a little broader, but not greatly swollen, leg IV. plainly longer than body, the femur reaching beyond the tip of abdomen, the tibia only about two-thirds as long as the metatarsus, the tarsus hardly one-third as long as the metatarsus, and only slightly swollen. The palpi short and not much enlarged, the claw rather short and slender, the thumb slightly clavate, reaching beyond end of claw, and with hairs about one-half as long as the width of the joint.

Length, 2 mm.

From Claremont, California.

Tarsotomus macropalpis n. sp.

A large species, rather sparsely bristly. Body nearly twice as long as broad, broadest at humeri; cephalothorax tapering in front, one eye spot each side close to margin and much nearer hind than front end of cephalothorax; legs long, but none of the femora as long as the cephalothorax, the tibia (penultimate joint), however, as long as the cephalothorax; body and legs with erect bristles, only a few very long ones, some on the basal joints are serrate or hairy, and the outer frontal pair, which are thicker than the others, also hairy. Claws with rows of bristles beneath; palpi very large and heavy, with two apical claws, the large one with a few teeth on inner side, hairs of thumb very short.

Length, .7 mm.

From Claremont, California, under rocks.

Tarsotomus terminalis n. sp.

Body slightly constricted in the middle, each part slightly rounded and a little broader than long; legs long and slender, the hind femur as long as abdomen, the hind tarsus one and one-half times as long as femur; front femur about as long as hind femur; palpi long, ending in a slightly curved, stout spur, thumb long, but also heavy. Body and legs (except tarsi) with many very long, nearly erect bristles, two or three times as long as width of hind femur; tarsi with shorter, more appressed hairs. Cephalothorax with two eye spots each side.

Length, .4 mm.

From Claremont, California.

Eupodes brevipes n. sp.

Body yellowish (probably red when alive), legs hyaline. Body slender, pyriform, plainly more than twice as long as broad, much the broadest at humeri, above the hind coxæ the sides are concave, tip broadly rounded. Cephalothorax subtriangular, two long bristles each side, one on humerus, and two submedian rows down the back, about six bristles near tip of body. Leg I. no longer than body, femur I. not as long as the width of the body, tarsus I. plainly longer than penultimate joint which is no longer than the one preceding it. Leg IV. not as long as the body, the basal joints not much enlarged, tarsus IV. plainly longer than penultimate joint. All legs with a few simple bristles, mostly near tips of joints.

Length .45 mm.

From Laguna Beach, California, June 8th.

EXPLANATION OF PLATE

Figure 1. *Erythræus posticatus;* palpus, legs I. and IV.
Figure 2. *Trombidium perscabrum,* crista, palpus, and hairs.
Figure 3. *Tarsotomus macropalpis,* palpus, tarsal claws, and tip of mandible.
Figure 4. *Eupodes brevipes,* palpus and leg I.
Figure 5. *Tarsotomus terminalis,* palpus.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Mites From the Claremont Laguna Region

The mites listed below were collected during the years 1914 and 1915, chiefly in the fall. Those from Claremont were for the most part collected and mounted by Miss M. Shaw, Miss P. Jahraus and Mr. F. Cox. The mites from Laguna were collected by W. A. Hilton. The determinations were made by Dr. Nathan Banks, who describes several of the species as new in this issue. Immature forms were only determined to genus.

1. *Parasitus* sp. (nymph). Under leaves, Claremont. Cox, Shaw, Jahraus.
2. *Rhagidia pallida* Bks. Under stones, Claremont. Cox, Shaw.
3. *Erythræus* sp. (nymph). Under stones, Claremont. C. S. J.
4. *Tarsotomus terminalis* Bks. (this issue). Claremont, on live oak. C. S. J.
5. *Erythræus augustipes* (?) (nymph). Under stones, Claremont. J.
6. *Erythræus augustipes* Bks. Under stones, Claremont. S.
7. *Bella lata* Ewing. On live oak and under stones, Claremont. C. S. J.
8. *Erythræus augustipes* (?) (nymph). On live oaks, Claremont. C. S. J.
9. *Trombidium perscabrum* Bks (this issue). Palmers canyon, near Claremont. C. S. J.
10. *Eremæus bilamellatus* Hall. Claremont, under leaves. J.
11. *Tarsotomus macropalpis* Bks. (this issue). Claremont, under stones. S.
12. *Tarsotomus terminalis* Bks. (this issue). Claremont, under stones. J.
13. Hydracnid larva (large, bright red). On Notonecta, Claremont. H.
14. *Uropoda* sp. (nymph). Dark brown, closely massed on Scolopendra from Claremont. H. Fall of 1913.
15. *Erythræus augustipes* Bks. Under the bark of an eucalyptus tree. Claremont. H. Fall of 1913.

16. *E. posticatus* Bks. (this issue). Under the bark of an eucalyptus. Claremont. H. Fall of 1913.
17. Hydracnid larva, bright red on Notonecta. Laguna Beach. H. July, 1915.
18. *Parasitus* sp. (nymph). Dark reddish brown, on a large staphleinid beetle found about six miles from Laguna Beach. H.
19. Hydracnid larva, dark brown, found on a carabid beetle. Laguna Beach. H.
20. *Uropoda* sp. (nymph). Dark reddish brown, found on a carabid beetle, Laguna Beach. H.
21. *Hydracna* sp (?) "probably new." Banks. This large, dark brown spherical mite was found in great abundance on the pond weeds at the "Lakes," Laguna Beach. Specimens were collected in July and August, 1915. H.
22. *Eupodes brevipes* Bks. (this issue). Found under leaves in a canyon north of Laguna Beach. H.
23. *Eupodes brevipes* Bks. (this issue). Found at Laguna Beach, under stones. H.
24. *Erythræus* sp. (larva). Bright red, found abundantly on our most common phalangid. Palmers canyon. October, 1915. H.
25. *Erythræus* sp. (larva). Found abundantly on the neck folds and about the head of the common horned toad of Laguna. The hosts were collected high on the hills to the southeast of the laboratory. H.
26. *Trombidium perscabrum* Bks. (this issue). Found in the fresh water of Aliso canyon, near Laguna Beach. Color, bright red. H.

W. A. Hilton.

(Contribution from the Zoological Laboratory of Pomona College)

The Central Nervous System and Simple Reactions of a Rare Whip Scorpion

WILLIAM A. HILTON

A number of specimens of *Trithyreus pentapeltis* Cook were collected by the writer in the college park at Claremont. The only other record of any member of this family found in the United States is the early paper of Cook which describes this species from Palm Springs, California. At another time there will be published a description with figures of the general external anatomy of this interesting creature. Fig. 1 is partly from an outline drawing by Miss Margaret Moles. The general position of the nervous system is shown in the outline. So far as we could determine there were no sense organs but hairs. These for the most part were of the usual arthropod type, but there were several modifications of them as will be shown by Miss Moles at a later time. The hairs are most abundant under the body and are probably important organs for giving sensations from the surfaces where the animals run. The most remarkable hair sense organs are on the legs. The figure shows the position of these slender delicate structures, two on the first leg, one on the others. If an animal is approached by any object one of these hairs is apt to be touched, especially if attempts are made to seize the animal. At first it was almost impossible to believe that the little creatures did not have eyes, they so well avoided all attempts to capture them with forceps. When approached by some object which probably touches one of the long hairs they run either backwards or forwards apparently with great accuracy determining the position of the approaching object. However their backward running is most marked and most remarkable. They run with great swiftness in a backward direction in some cases for several inches. I found little evidence of other sense organs than those of touch. They did not especially avoid strong odors, but after a rather long exposure to strong light or heat they sought refuge under some object.

Although the chitin is thin in places the first attempts at serial sections through the whole body were not very successful. It was

found possible to remove the complete nervous system intact after a few trials. All figures are from such removed nervous systems. As the animals are small, being only a few millimeters in length, no branches but the chief ones could be preserved or shown in the figures. The nervous system resembles that of Thelyphorus as described by Börner, but as the animals are less complicated it is simpler. As in Börner's description there is brain or supræsophageal ganglion, a mass below the esophagus which supplies all of the thoracic region and a single abdominal ganglion. The brain or superior ganglion has but one branch on each side leading from it, this pair leads into the jaw-like first appendages. The other five pairs of branches lead off from the ventral ganglion. The first two pairs of branches come off practically at the junction of the dorsal and ventral ganglia. The connection between the dorsal and ventral parts of the head-thoracic ganglia is very broad. The cells are small and of a uniform size for the most part. They are grouped in areas as shown in methylene blue preparations from which Figs. 3 and 4 are taken. The general position of the cells is much like that in other arachnids. The central fibrous mass is quite homogeneous in the ventral ganglionic portion, but is broken into a number of partly isolated portions especially at the margins. At the very caudal end laterally there is a very characteristic lobe of fibers on each side. This lobe may represent the posterior globus of Haller although there are no smaller cells near. Other irregular masses are shown in the figures. They resemble parts of the stalks of mushroom bodies. In the cephalic dorso-lateral regions there are two conspicuous groups of cells located below the main mass of cells and separated somewhat from each other, prominent fibers connect these areas with lower levels. These may represent the anterior globuli described by Haller, 1912, but these are of larger instead of composed of smaller cells. I have found nothing like them in arachnids. They may be something like the mushroom bodies of insects.

SUMMARY

1. *Trithyreus* has no sense organs but sensory hairs, so far as could be determined.

2. The central nervous system resembles that of a spider quite closely, but the thoracic ganglion is more elongate and there is an abdominal ganglion.

3. The brain is complicated, but few long tracts of fibers are evident.

4. There may be areas which may represent anterior and posterior pairs of globuli of spiders and scorpions, but if so they do not have the same structure.

5. There are no trachea in the central nervous system.

6. The cells are uniform except for a mass each side of the brain in a cephalic dorsal position.

7. This dorso-lateral group of cells strongly suggests a special higher center. Longer fibers were seen in connection with it than with any other part.

REFERENCES

Börner, C. 1904
Beitrage zur Morphologie der Arthropoden. Zoologica. Heft 42.

Cook, O. F. 1899
"Hubbardia": A new genus of Pedipalpi. Proc. Wash. Ent. Soc. Vol. IV.

Haller, B. 1912
Uber das Zentralnervensystem des Skorpions und der Spinnen. Archiv f. Mic. Anat. Bd, 79. Abt. I.

(Contribution from the Zoological Laboratory of Pomona College)

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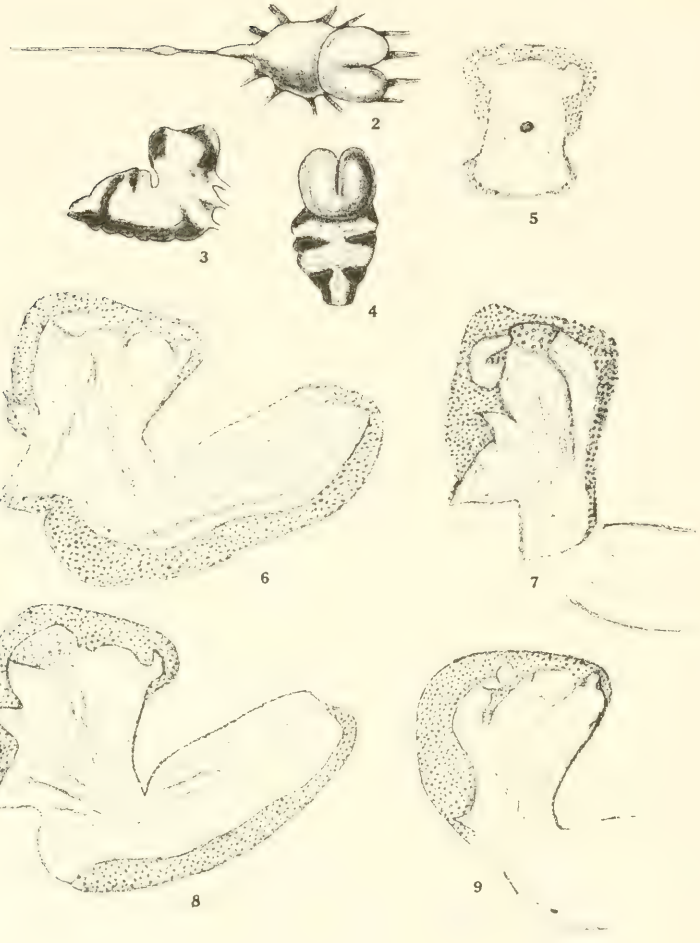
Figure 2. Central nervous system removed. X20.
Figure 3. Side view of methylene blue preparation showing position of the cells. X20.
Figure 4. Dorsal view of Fig. 3.
Figure 5. Cross section through the caudal region of the central nervous system. X75.
Figures 6 to 9. Longitudinal sections through the cephalic ganglia. Cephalic side to the left, dorsal side up. Fig. 6, near the center, Figs. 7, 8, and 9 lateral sections. X75.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Three Common Spiders of Laguna

Margaret L. Moles

Plate I. *Argiope argentata* Fabricus. Female.

A. argentata was collected abundantly on the sage-brush and cactus. The webs are very large, irregular orbs. The position taken by the spider when on the web is very characteristic. The spider hangs in the center of the web, its forelegs straight beside the head, the hind legs horizontal with the cephalothorax. Colonies of these spiders were found in the center of a clump of cactus. In one small clump there were found five (5) adults on webs and numberless small ones with webs started or partially completed. *A. argentata* is very quick in its movements and drops to the ground as soon as touched.

Individuals differ in the markings of the abdomen. The differences seem to be mainly in the amount of black coloring on the lower part of the abdomen. In some specimens the silvery white color being everywhere except on the tips of the last three (3) tubercles and the black folium.

This species has been collected also in Claremont, but not so abundantly.

Plate II. *Tetragnatha laboriosa* Hentz. Female.

This little spider was found on everything and everywhere. It was especially on tar weed, but also inhabited honeysuckle, grass and all the other flowering plants of the dry hills and mesas around the beach. There were very few differences among the different individuals as to markings or colors, though in some the folium on the abdomen was darker than in others, and the shades of yellow on the legs and cephalothorax varied slightly. The spider did not spin a web to live in nor to help in catching food, but depended upon its own speed to gather in flies and insects. This species was by far the most common of all the spiders collected at Laguna. It has also been collected in Claremont, but only a few times.

Plate III. *Gasteracantha maura* McCook. Female.

This species was collected on sage brush which grew on the hills and bluffs at Laguna Beach. The web was a small orb and spun right near the top of the bushes. Collectors could not fail to see these small spots of bright color hanging as it seemed in midair among the bushes.

The specimens collected differed in color and color pattern. The color on the abdomen varied from dark orange to light lemon yellow. The black spots on the upper edge of the abdomen and on the lower tubercle are sometimes fused together, the ones on the upper edge making an irregular line, while those on the tubercle make a large, irregular spot. This species was fairly common and abundantly collected in July. It has been collected in Claremont also, but not so abundantly.

(Contribution from the Zoological Laboratory of Pomona College)

Plate I. *Argiope argentata* Fab

Plate II. *Tetragnatha laboriosa* Hentz

Plate III. *Gasteracantha maura* Mc Cook

Crab-Spiders of the Claremont-Laguna Region

MARGARET L. MOLES

In the Claremont region, spiders belonging to the family Thomisidæ are very abundant. Though great in numbers only five genera of the family have been found. During the months of May and June they frequent the poppies and feed upon the small Hymenoptera and Diptera, which come to the flowers. A great many were found in the flowers with dead bees, showing that the spiders grabbed at the large prey resulting in the death of both. They are very wary, the instant a shadow falls on the poppy plant they run to the under side of the flower and drop to the ground. The coloring of the spiders is so protective that when they are down among the stamens of the flowers it is hard to distinguish them unless closely observed. The species that were found to frequent the poppies were *Misumena aleatoria, Misumenops asperatus* and *Xysticus californicus*. The wild flowers which have the colors blue, red or lavender were never found to be inhabited by any members of this family, but nearly all the wild flowers of a yellowish hue had from one to two thomisids in them. A great many young were found during the months of May, June and July.

Xysticus californicus, Philodromus pernix and *Xysticus gulosus* were found under the bark of tree, *Xysticus californicus* being found in the tall grass, under the bark of the eucalyptus trees and in poppies. *Philodromus pernix* and *Xysticus glusosis* were found under eucalyptus bark, oak bark and sycamore.

Misumena aleatoria was found on tar weed, poppies, in a dried-up yellow rose and in a pink rose. The one found in the drie-up yellow rose (Plate I) was remarkable in its protective coloring, looking exactly like a dried yellow rose petal in the dark brown stamens. Two variations in coloring were found in *Misumena aleatoria*. One which was found in the green grass had a brownish green body and lacked any dark spots on the abdomen, the other was a yellow color with only one dark brown spot on the abdomen, the head and

thorax showed no trace of black, there were no wrinkles on the abdomen and the legs were a light yellow green. This one was found on the honeysuckle and resembled as near as possible the coloring of the honeysuckle flower and vine. We have Dr. R. V. Chamberlin to thank for the determination of most of the specimens studied. No results of the study of color changes are given at this time.

A LIST OF CLAREMONT CRAB-SPIDERS

Misumena alcatoria (Hentz). Found on old yellow rose bushes, pink rose bushes and tar weed.

Misumenops asperatus (Hentz). Found on poppies and tar weed.

Philodromus pernix (Blackwall). Found under bark.

Xysticus californicus (Hentz). Found under bark, in grass and in poppies.

Xysticus gluosus (Key). Found under bark of eucalyptus trees, sycamore trees and oak trees.

Xysticus triguttatus (Key). Found in the grass and low bushes, Palmer's canyon.

Thanatus coloradensis (Key). Collected by Baker and listed by Banks in his article in the Proc. Acad. Nat. Sci., Phila., 1901, p. 585.

Tibellus duttonii (Hentz). Found on mustard about Claremont.

(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF PLATES

Plate I. *Misumena aleatoria* (Hentz). Found in yellow rose. Yellow crinkled body. Dark brown abdomen spots. Collected September, 1915.

Plate II. *Misumena aleatoria* (Hentz). Found on rose bush, in a partly dried-up rose. Collected October, 1915.

Plate III. *Misumenops asperatus* (Hentz). Found on tar weed. Hemizonia.

Plate IV. *Philodromus pernix* (Blackwall).

Plate V. *Xysticus gulous* (Key). Found on bark of sycamore.

Plate I

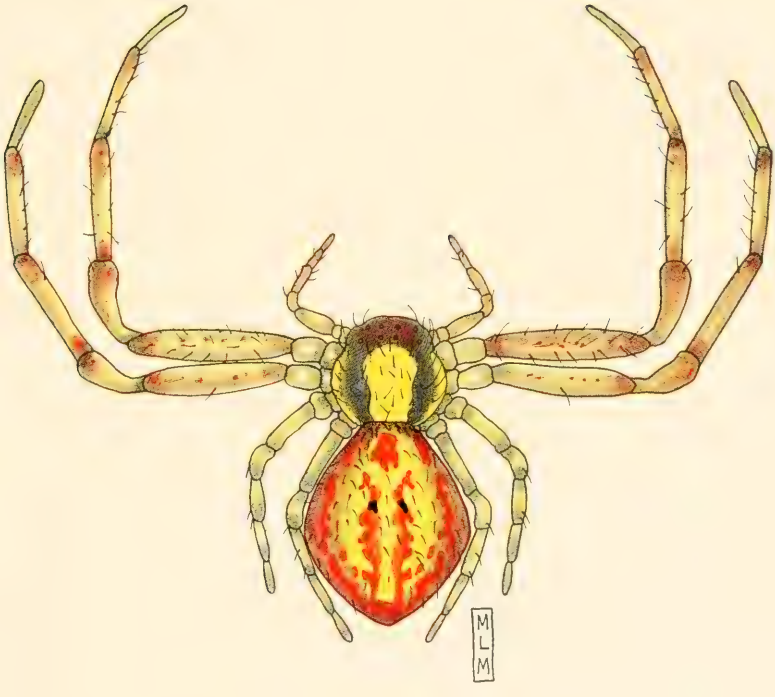


Plate III

Plate II

Plate IV

Plate V

1916 Pomona Journal of Entomology and Zoology, Vol. VIII, No. 2, June

Lima Dehiscens at Laguna Beach

MARGARET L. CATE

This interesting mollusk was obtained several times during the Summer of 1915. Its activities were observed in the aquarium. It usually remained in an expanded condition. Its movements were caused by forcing water out of the siphons not like the movements of Pecten. The reproduction of the drawing given at this time is not quite the right color of pink.

(Contribution from the Zoological Laboratory of Pomona College)

Lima dehiscens Conr.

The Octopod *Ocythoe* in California

S. S. BERRY

In the course of my review of the West American cephalopods published a few years ago (Bulletin Bureau Fisheries, v. 30, p. 275), I wrote of a well known group of pelagic Octopoda as follows:

"No other group at all approaches *Argonauta* in its assemblage of utterly distinctive characters, the nearest being the genera *Ocythoe* and *Tremoctopus,* which are not known to be represented in our waters."

That *Ocythoe,* at least, is a member of our fauna, I have long suspected, partly because of a specimen which was exhibited in one of the Los Angeles curio stores some years since, but ignorantly held at so inflated a figure, that it could not be obtained even for one of the university museums, and another without label, but thought to be from Southern California, which is now in the collection of the State University at Berkeley. A further bit of evidence, which to me savors strongly of this same animal, lies in a paragraph by the late Dr. C. F. Holder with regard to a specimen obtained by him at Avalon (Scientific American, October 16, 1909, p. 283). He wrote:

"It is given in all the textbooks, I believe, that the male of the argonaut is a minute animal hardly an inch long. This cannot be so in all species. I have a male which has a radiant spread of eight or nine inches, and is as large as the female. . . . The male of this species is large, and might readily be taken for an octopus, having its habits."

As a male *Argonauta* answering such a description as this would be a sheer absurdity, the lines quoted served at first to occasion me no little perplexity. Surely, however, the suggestion that Holder's specimen was a female *Ocythoe* and not an *Argonauta* at all, seems not only possible, but plausible.

These cases are all strong indications that *Ocythoe* belongs to our fauna but, in view of the obvious uncertainty attending each, no formal record of the fact has yet found its way into print.

A very large and finely preserved female, recently sent me by Prof. William A. Hilton, now settles the matter without question. This specimen (S. S. B. 453) was obtained from near Avalon, Santa Catalina Island, California, in the summer of 1915, by Mr. W. F. Hamilton. Unfortunately I have no comparative material from other regions available, so that with only the aid of such figures and printed descriptions as are at hand, the specimen cannot be distinguished from the Mediterranean *O. tuberculata,* described and named by Rafinesque just over one hundred years ago. As *tuberculata* happens to be the only species of the genus enjoying general recognition, and as it is a pelagic creature with the possibility of very wide dissemination, the identification seems nevertheless to be reasonably certain, though it should be admitted that the areas it is alleged to inhabit are so widely separated that adequate material may later reveal differences which will be thought worthy of recognition.

In addition to Mediterranean localities the species has been reported from Vineyard Sound, Massachusetts, from the West Indies, and from Japan.

The sexes in this genus, as in the related *Argonauta* and *Tremoctopus,* show such extreme dimorphism, that the description of one applies in scarcely a single particular to the other. The female *Ocythoe,* however, is very easily distinguished from other cephalopods by the large Octopus-like body, the ventral surface of which is very curiously ornamented with numerous conspicuous cartilaginous tubercles, connected by radiating ridges. The enormous and powerful funnel is also noteworthy.

The more important measurements of the present specimen are appended below, many of them necessarily more or less estimated.

MEASUREMENTS

Total length	440 mm.
Length of body (dorsal)	160 mm.
Length of body (ventral)	155 mm.
Tip of body to base of dorsal arms	170 mm.
Width of body	115 mm.
Width of head	74 mm.

Length of head	10 mm.
Length of funnel	64 mm.
Width of funnel opening	12 mm.
Length of right dorsal arm	275 mm.
Length of left dorsal arm	265 mm.
Length of right second arm	200 mm.
Length of left second arm	195 mm.
Length of right third arm	180 mm.
Length of left third arm	185 mm.
Length of right ventral arm	250 mm.
Length of left ventral arm	240 mm.
Diameter of largest suckers	9 mm.

New Californian Bees

By T. D. A. Cockerell

In a small collection of bees recently received from Pomona College, I find four new species, which are described herewith.

Tetralonia pomonæ sp. n.

♂ Length 10 mm., black with the clypeus pale lemon yellow, notched at sides; labrum pale yellow, but mandibles entirely black; antennæ black, flagellum reaching end of second abdominal segment; third antennal joint a little longer than broad; eyes (dry) very dark brown; face broad, covered with long dull white hair; thorax above with very pale ochreous hair; disc of mesothorax brilliantly shining, feebly and sparsely punctured; tegulæ fuscous with a rufous spot posteriorly; wings dusky hyaline; nervures rufopiceous; second s. m. narrowed above, receiving first r. n. a little beyond beginning of last third; legs with dull white hair, orange-ferruginous on inner side of tarsi; small joints of tarsi clear ferruginous, but basitarsi at most obscurely reddened apically; hind spur normal; abdomen with hind margins of segments narrowly hyaline; first segment with long pale hair; second with thin pale hair basally, but short fuscous hair subapically; third like second, but with a definite basal band of dull white tomentum; fourth covered with dull white tomentum, but a little fuscous hair just before margin; fifth like fourth, except that hind margin has a dense white fringe, and no fuscous; apical plate ferruginous, with fulvous hair on each side.

Hab.—Laguna, California (*R. La Follette*, B 2). In my tables in Trans. Amer. Ent. Soc., 1906, this runs to *T. lepida,* but it has not the narrow face of that species. It resembles *T. birkmanniella* Ckll. and *T. poetica* Ckll., but the three are easily separated thus:

Flagellum about 12 mm. long, reaching beyond end of third abdominal segment; upper margin of clypeus broadly black. *poetica* Ckll.

Flagellum 10 mm. or less; upper margin of clypeus not black. 1.

1. Second s. m. a little broader above than below; apical plate of abdomen broad at end; hair on outer side of hind basitarsi scanty and rather short. *birkmanniella* Ckll.

   Second s. m. narrower above; apical plate of abdomen narrow at end; hair on outer side of hind basitarsi abundant and long. *pomonæ* Ckll.

Diadasia crassicauda sp. n.

♂ Length about 10 mm.; black, with abundant though not very dense grayish-white hair; eyes narrow, grayish-green; face broad; clypeus shining, with fine punctures; flagellum entirely black; mesothorax shining, with small punctures very sparse on disc posteriorly; area of metathorax microscopically sculptured, with an opaque median sulcus; tegulæ reddish brown, blackened anteriorly; wings hyaline, slightly reddish; legs black, with long white hair, small joints of tarsi obscurely reddish; hind basitarsi gently curved, but not produced at end; first two abdominal segments with long loose pale hair, the others with appressed hair, and segments 2 to 6 with narrow white marginal bands; apex of abdomen bilobate, the lobes large and blunt, covered with very pale ochraceous hair except at the ends, which appear black; stipites with long red hair on posterior margin.

Hab.—Laguna, California (*R. La Follette,* B 7). Allied to *D. sphæralcearum* Ckll., but larger, with very much broader lobes at end of abdomen, those of *sphæralcearum* being spine-like. It does not seem probable that this is the male of *D. albovestita* Provancher.

Exomalopsis nitens sp. n.

♀ Length about or nearly 7 mm.; robust, black, mandibles dark red in middle, flagellum ferruginous beneath except at base; hair of head and thorax rather long, dull white, pale ochraceous dorsally; head and thorax shining, finely punctured; tegulæ piceous; wings grayish hyaline, nervures dark, stigma sepia; legs black, with small joints of tarsi ferruginous; scopa of hind legs large and beautifully plumose, dull whitish on tibia, gray (variably dark) on tarsi; first abdominal segment shining, the basal declivity bounded above by a distinct rim, the hind margin at each side with a broad, dense

white hair-band, wholly absent from the middle half; segments 2 to 4 with very broad entire bands of grayish-white tomentum; apex of abdomen with ochreous hair.

Hab.—Laguna, California (*R. La Follette,* B 5, B 8). In Friese's table of *Exomalopsis* (1899) this runs to *E. texana* Friese, but that is a much smaller species, with quite differently colored tegulæ and stigma. *E. texana* belongs to the genus or subgenus *Anthophorula* and *E. nitens* is doubtless to be referred to the same group, although the male is unknown. It is quite distinct from *A. coquilletti* (Ashm.), which Baker has taken at Claremont.

Augochlora pomoniella sp. n.

♀ Length about 8 mm.; bright emerald green, face tinted with golden, mesothorax bluer green, abdomen yellowish-green; clypeus strongly punctured, broadly black apically; mandibles with a small green spot at base; face very broad, eyes deeply emarginate (about as in *A. pura,* much more so than in *A. confusa*); front extremely finely and densely punctured; anterior lateral corners of prothorax rounded; tubercles prominent; mesothorax very finely and densely punctured; area of metathorax with many fine short plicæ, but the margin thickened, obtuse, without definite sculpture; tegulæ piceous, pallid anteriorly; wings dusky hyaline, nervures fuscous, stigma very dull ferruginous; first r. n. meeting second t. c. or entering extreme base of third s. m.; hair of head and thorax above scanty, dull white; femora largely green, tibiæ and tarsi black, anterior tibiæ with metallic tints in front; hind spur of hind tibia appearing simple under a lens, but the margin actually with about 20 little nodules; abdomen shining, very finely punctured, the first two segments with a hardly noticeable dark margin; fifth segment dark blue-green, with fuscous hair; venter black.

Hab.—Aliso Canyon, California (*R. La Follette,* B 15). A species of the group of *A. pura* and *A. confusa.* From *A. pura (robertsoni)* it is known by the much smoother, more finely punctured supraclypeal area, the thick rounded rim of area of metathorax and the dark nervures. From *A. confusa* it is known by the deeply emarginate eyes, broad face, much shorter plicæ of metathorax and dark nervures. From *A. neglectula* by the much broader head,

smooth and brilliantly shining posterior truncation of metathorax, etc.

At the same locality Mr. La Follette took *Agapostemon radiatus* Say (B 16) and *Halictus farinosus* Smith (B 1, B 11); the latter also at Laguna (B 3). Aliso Canyon is about two miles from Laguna Beach.

The specific name chosen, connecting the species with Pomona College, should in strictness be written *pomonæella,* but the derivation is ultimately from pomum, and it seems permissible to choose the less cumbersome form.

New and Little Known Bees From California

By T. D. A. Cockerell

The bees described and listed below are from the Baker collection, and were kindly transmitted to me by Professor Wm. A. Hilton. All are from Claremont or the vicinity.

Glossoperdita gen. nov.

Like *Perdita* Smith in general structure and appearance, but mouth-parts enormously elongated, apparently not retractile, the end of the tongue reaching beyond tip of abdomen; maxillary palpi 6-jointed, slender and very short, about 300 microns long; maxillary palpi about 1280 microns from base of mouth-parts, the blade extending about 3200 beyond the palpi, but the labial palpi not correspondingly elongated, their ends only about 800 microns beyond insertion of maxillary palpi. Head narrow, facial quadrangle conspicuously longer than broad; facial foveæ elongate and deep, ending below about level of insertion of antennæ; b. n. falling far short of t. m.; second s. m. very broad (long) but much narrowed above; stigma small and narrow; marginal cell long for the group, broadly truncate at end.

Glossoperdita pelargoides sp. n.

♀ Length about 5 mm.; not very robust; pubescence scanty, white; head and thorax blue-green, but the mesothorax only green in front, the greater part, as well as the scutellum, black; clypeus and supraclypeal area black, sparsely and distinctly punctured; the face apparently without light markings, but close inspection shows a broad shadowy pallescent band in middle of clypeus, and similar triangular pallescent lateral marks, hardly visible; flagellum bright ferruginous beneath except basally; front dull; mesothorax shining anteriorly, the median groove deep; pleura polished, shining; tubercles pale reddish, two small pale marks on upper border of prothorax; legs piceous, hairy, anterior knees and band on tibia pale yellowish, middle knees pale reddish; tegulæ reddish; wings short,

somewhat dusky, stigma and nervures pale sepia; abdomen orange-ferruginous, without markings above or below, hair at apex pale ochreous.

Habitat: Claremont, California (*Baker;* Pomona coll. 227 part). Unfortunately the habits of this remarkable bee are unknown. *Glossoperdita* could be considered a subgenus of *Perdita,* but it seems distinct enough to deserve generic rank.

The other specimens collected by Baker at Claremont sent under 227, are marked as from flowers of *Rhus laurina.* They consist of *Perdita rhois* Ckll., and a single male *P. hypoxantha* Ckll., the latter presumably a stray, as the species is attached to *Adenostoma.* Also under 227 is a female of *P. albipennis* Cress., collected by Baker at Los Angeles, and bearing his number 691.

Perdita ruficauda, sp. n.

♀ Length about 5.5 mm., moderately robust, pubescence scanty; head and thorax dull olive green; head ordinary, inner orbits parallel; mandibles pale yellow suffused with reddish, the apex black; clypeus black, sparsely punctured, with a broad pale yellow median band, failing below; no supraclypeal mark; lateral marks pale yellow, triangular, produced above, ending in a sharp point on orbital margin at level of antennæ; flagellum pale fulvous beneath; tubercles yellow with a dark dot, and a pair of cuneiform yellow marks on upper border of prothorax; mesopleura shining; legs piceous, with anterior and middle knees, tarsi and tibiæ yellow, the latter dark behind; tegulæ pellucid; wings faintly reddish, stigma and nervures reddish-brown; stigma small and slender; marginal cell large, obliquely truncate at end; abdomen bright orange-ferruginous above and below, without markings, except a narrow dark stripe along lateral margins of second segment. Mouth-parts not especially elongated; labial palpi with first joint about 690 microns, the other three together about 290 microns. Maxillary palpi long and well-developed.

Habitat: Claremont, California (*Baker;* Pomona coll. 229, 199). This superficially resembles *Glossoperdita.* In my tables of *Perdita* it falls near *P. chamaesarachæ,* from which it is at once known by the face-marks and the palpi.

Halictoides mülleri Ckll.

Both sexes were taken by Baker at Claremont.

Hesperapis nitidulus sp. n.

♂ Length a little over 6 mm.; shining black, with white hair; eyes pea-green; mandibles broad, red and notched at end; head large and broad; flagellum very obscurely reddish beneath; tegulæ piceous in front, testaceous posteriorly; wings hyaline, nervures and stigma dusky ferruginous; abdomen with rather thin hair-bands. near to H. *larreæ* Ckll., but mesothorax with very minute regular punctures; area of metathorax dull and abdomen more shining. Easily known from *H. oliviæ* Ckll. by the clearer wings and dark antennæ.

Habitat: Claremont, California (*Baker;* Pomona coll. 229).

Agapostemon californicus Crawford.

Claremont (*Baker*). A male with the scape all dark; it usually has a yellow stripe in this species. *A. radiatus* Say was also taken by Baker at Claremont.

Panurginus atriceps (Cresson)

Mountains near Claremont (*Baker;* Pomona coll. 204).

Andrena osmioides sp. n.

♂ Length about 10 mm., robust, very hairy, looking like an *Osmia;* head, thorax and legs black, abdomen olive-green, the surface minutely granular, not polished or punctate; hair of head and thorax white, dullish and faintly creamy above, very long and abundant, forming an immense white beard over mouth; abdomen with erect or sub-erect pale hair, all over the surface but not dense, long on the first two segments, apex with pale soot-colored hair; legs with pale hair. Head extremely broad, facial quadrangle very much broader than long; malar space very short; cheeks very broad, obtusely angled behind below level of middle of eye; antennæ ordinary, third joint equal in length to next two combined; flagellum very obscurely reddish beneath; vertex dull, only shining on orbital margin; mesothorax dull, not punctate, but scutellum anteriorly shining; area of metathorax dull and granular, with long erect hairs like the adjacent parts; tegulæ piceous; wings dusky on apical mar-

gins; stigma narrowly lanceolate, very slender, ferruginous with dark margin; b. n. meeting t. m.; first r. n. joining second s. m. much before middle; second abdominal segment depressed less than a third; venter purplish.

Habitat: Claremont, California, at flowers of *Cryptanthe* (*Baker;* Pomona coll. 198). Easily known among the species with green abdomen by its large size, abundant long pale hair, and very slender stigma.

In the mountains near Claremont Baker took *A. mimetica falli* Ckll., and at Claremont *A. prunorum gillettei* Ckll.

Andrena prunorum var. *mariformis* v. n.

♀ Clypeus pale yellow with two black spots, exactly like that of a male. The hair on head and thorax above is fine fox-red; the abdominal hair-bands are pale fulvous. Scape partly red, especially at apex; flagellum wholly dark. Second abdominal segment with a large black discal patch.

Habitat: Claremont, California (*Baker;* Pomona coll. 207). This is not stylopized. Can it be a partial gynandromorph? All the characters, including the antennæ, are those of a female, except the clypeus.

Andrena peratra sp. n.

♀ Length about 10.5 mm.; entirely black, with black hair, except perhaps partly on mesothorax, which is denuded in type; head very broad, facial quadrangle very much broader than long; malar space very short; process of labrum obtusely pointed; clypeus delicately roughened, with rather close weak punctures, no smooth line; front minutely striate; facial foveæ dark seal brown, occupying more than half the distance between antennæ and eye, ending below, far below level of antennæ; third antennal joint considerably longer than next two combined; flagellum obscure reddish beneath except at base; mesothorax dull, granular, with no distinct punctures; area of metathorax granular; pleura with long reddish-black hair; small joints of tarsi reddish; tegulæ piceous, largely ferruginous posteriorly; wings translucent reddish, not dark; stigma ferruginous, narrowly lanceolate, extremely slender; nervures fuscous; abdomen granular, without evident punctures, but moderately shining; second

segment depressed about a fourth; hair at apex reddish-black; ventral segments with long fringes of stiff black hairs.

Habitat: Claremont, California (*Baker;* Pomona coll. 199). This may be compared with *A. nigerrima* Casad, from which it is readily known by the non-punctate abdomen and other characters.

A related but much larger species of the Los Angeles region is *A. subtristis* Ckll. This, according to Mr. Viereck, is a synonym of *A. nigra* Prov., and the specimens in the National Museum labeled *nigra* are this species. There is, however, some confusion, since Provancher's description indicates a smaller species (length .42 inch), with a smooth line in middle of clypeus (wholly wanting in *subtristis,* but present in the much larger *pertristis* Ckll.), wings smoky reddish (like *pertristis* rather than *subtristis*), and abdomen oval and brilliantly polished. This indicates a species unknown to me.

Andrena auricoma Smith

Claremont (*Baker;* Pomona coll. 197). Smaller than an Oregon specimen. *A. candida* Sm. was also taken by Baker at Claremont (Pomona coll. 198).

Andrena plana Viereck

Claremont (*Baker;* Pomona coll. 212). This is a little larger than Viereck's type, but is presumably his *plana,* having the very remarkable brownish velvet-like hair on thorax above, and the dull impunctate clypeus. The second abdominal segment has no apical depression. Superficially the species resembles *A. mustelicolor* Vier., but it is easily separated by the thoracic hair.

Andrena opaciventris sp. n.

♀ Length about 10 mm.; black, with fulvous hair, bright fox-red on thorax above; face and front with much fulvous hair, so that the dull granular surface of the clypeus is difficult to see; mandibles black, with a red spot at extreme base; process of labrum narrow at end, minutely notched; facial foveæ grayish-brown, about half as wide as distance between antenna and eye, difficult to see on account of the long overlapping hair; antennæ black, third joint 368 microns long, the next two together 384 microns; mesothorax and scutellum

dull, without distinct punctures; area of metathorax dull, defined by absence of hair; hair at sides of metathorax very long and curled; legs with pale hair, largely chocolate on outer side of middle and hind tibiæ, pale orange on inner side of basitarsi; spurs pallid; tegulæ black; wings slightly dusky, stigma ferruginous, nervures fuscous; b. n. meeting t. m.; first r. n. joining second s. m. about middle; abdomen broad, with a completely dull impunctate surface; first segment with long fulvous hair at base, and a patch on each side on hind margin; segments 3 to 5 with conspicuous entire fulvous hair-bands; apex with pale soot-colored hair, a sort of reddish-gray; second segment depressed about a third, but the depression obscure.

Habitat: Claremont, California (*Baker;* Pomona coll. 197). Resembles *A. auricoma,* but very distinct by the opaque abdomen.

Andrena chlorura sp. n.

♀ Length nearly 8 mm.; olive green, the metathorax, legs and antennæ black; pubescence fulvous, bright fox-red on thorax above and tubercles; some thin black hair on front and vertex; process of labrum very broad and rounded; clypeus with sparse weak punctures; facial foveæ black, rather narrow, ending below at level of antennæ; third antennal joint longer than next two together, but not so long as next three; mesothorax dull, impunctate; area of metathorax dull; tegulæ piceous; wings dusky; stigma large, dark reddish; nervures fuscous; abdomen shining, impunctate, with thin narrow fulvous hair-bands on segments 2 to 4, but none on first; hair at apex black; second segment depressed about a third in middle, but very narrowly at sides.

Habitat: Mountains near Claremont, California (*Baker;* Pomona coll. 197). A pretty species, known among the green Andrenæ by its red hair and small size. In Viereck's tables of *Andrena* of the N. W. States it runs near to *A. chlorinella* Vier., from which it is quite distinct. According to Viereck (litt. 1907) *A. xanthostigma* Vier. is identical with *chlorinella.*

Diandrena beatula sp. n.

♀ Length 7 mm., or slightly over; olive green, with a minutely sculptured sericeous surface, not polished; pubescence dull white,

forming felt-like hair-bands on abdomen, weak on first segment, but broad and conspicuous on 2 to 4; hair at apex of abdomen very pale ochreous; mesothorax with thin felt-like pale ochreous hair, and a few long hairs intermixed; facial quadrangle broader than long; mandibles black; process of labrum deeply emarginate; facial foveæ light, with a slight ochreous tint; more than half as wide as distance from antenna to eye; apical two-thirds of flagellum bright red beneath; mesothorax dullish, granular; area of metathorax delicately plicatulate; tegulæ rufopiceous; wings faintly dusky; stigma dusky ferruginous, small and narrow; legs with white hair, hind tibiæ with a broad loose scopa; tegument of legs black; abdomen looking like that of the group of *Halictus* including *H. provancheri.*

Habitat: Claremont, California (*Baker;* Pomona coll. 216). A pretty little species, allied to the next, but easily known by the dullish fasciate abdomen.

Diandrena cyanosoma sp. n.

♀ (Type.) Length about 8 mm.; head olive green, thorax and abdomen blue green, the abdomen almost blue; clypeus black, with the upper and lateral margins green, the junction of the black and green suffused with purple; mandibles black; pubescence dull whitish; slightly ochreous on head and thorax above, fuscous or black just behind ocelli and more or less on front, and long dark hairs on scape; process of labrum narrow, emarginate; antennæ dark, the flagellum only very obscurely reddish toward end; facial foveæ pale, quite broad; mesothorax dull and granular, with short hair, and some long ones intermixed; scutellum rugosopunctate, but glistening anteriorly; area of metathorax roughened with very delicate rugæ; femora olive-green; tibiæ and tarsi black; hind tibiæ with a long glistening pure white scopa beneath, but fuscous hair above (behind), and hind knee-tuft grayish fuscous; hind trochanters with a long white curled floccus; tegulæ piceous; wings dusky, stigma dark reddish, rather small; abdomen broad, without any distinct hair-band, though the fourth segment has a thin fringe; hair at apex soot-color.

♂ More slender, with the usual sexual differences. Clypeus and middle of face densely covered with long white hair, but some

long fuscous hair at sides of front and on scape; cheeks with long white hair; mesothorax and scutellum with thin long erect white hair; abdomen quite without bands, hair at apex dark grayish-fuscous.

Habitat: Claremont, California (*Baker;* Pomona coll. 203, 229). A distinct species, readily known from *D. puthua* Ckll. (male) by the dark hair at apex of abdomen. The dull surface of the abdomen at once separates it from the two following species.

Diandrena clariventris sp. n.

♂ Length a little over 6 mm., robust, with broad-pyriform abdomen; head and thorax dull blue-green; legs black, the femora perhaps faintly metallic; abdomen polished, shining, very dark blue-green, the hind margins of the segments broadly subtranslucent brown; head very broad, facial quadrangle much broader than long; antennæ only moderately long, flagellum dark reddish; face and front with pure white hair, hair of thorax also white, no dark hair on head or thorax; area of metathorax granular, faintly plicatulate basally, and with a faint median raised line; tegulæ piceous; wings dusky; stigma and nervures reddish-fuscous, the stigma dark, not very large; hair at apex of abdomen very pale, with an ochreous tint.

Habitat: Claremont, California (*Baker;* Pomona coll. 212). Allied only to the next species, which is much smaller. *D. chalybæa* (Cress.), also taken by Baker at Claremont, has the abdomen shining blue.

Diandrena scintilla sp. n.

♀ Length about or hardly 5 mm., robust, with very broad abdomen. General characters as in *D. clariventris,* but much smaller; head nearly circular, seen from in front; flagellum very short and stout, the middle joints about twice as broad as long, dark reddish beneath; front shining, punctate; mesothorax and scutellum olive-green, shining, with distinct minute punctures; area of metathorax concave, finely striatulate; stigma and nervures paler than in *D. clariventris,* and wings not so gray; punctures on second abdominal segment sparse; hair at apex of abdomen light ferruginous.

Habitat: Claremont, California (*Baker;* Pomona coll. 213). Close to *D. clariventris,* but certainly distinct, the sculpture of the thorax being quite different.

Conanthalictus bakeri Crawford.

♂ About 4 mm. long; hair at apex of abdomen reddish-gray, abundant. The six-jointed maxillary palpi are very long and slender, and the tongue is linear, quite long, with very long hairs.

♀ I made the following notes from Crawford's type in U. S. National Museum. Dull green abdomen, hind margins of segments pale reddish; head round seen from in front; front dull bluish green; long hairs over clypeus like a moustache; mesothorax not evidently punctured. Has the short elevated clypeus of genus, but head differently shaped. The Claremont specimen shows a well-developed tibial scopa.

Two males and a female are before me, from Claremont (*Baker;* Pomona coll. 199, 216). The genus seems nearest to *Paralictus* Rob., but quite distinct. Both are without the caudal rima in female.

Conanthalictus macrops sp. n.

♂ Length slightly over 4 mm., but more robust than *C. bakeri,* with the reddish hind margins of abdominal segments fringed with white hair except in middle; head very broad, the facial quadrangle much broader than long; mandibles broadly red at apex; antennæ short, entirely dark; cheeks rather broad, with a depressed, dimple-like area; front completely dull, but mesothorax somewhat shining, though not polished; wings strongly dusky; stigma dark reddish, rather small; nervures fuscous; second s. m. very narrow; femora green, tibiæ and tarsi black, with white hair. The green color, fine sculpture, etc., are as in *bakeri.* The abundant hair at apex of abdomen is pale dusky reddish.

Habitat: Claremont, California (*Baker;* Pomona coll. 199). Known from all other members of the genus by the very broad head. The large black eyes are parallel.

Augochlora pomoniella Ckll.

Both sexes from Claremont (*Baker;* Pomona coll. 211, 210). The male is new.

♀ Antennæ entirely dark, flagellum with only the faintest red tint beneath toward the apex.

♂ Flagellum ferruginous beneath, except first and last joint; mesothorax polished, with well-separated punctures; first ventral segment of abdomen green with piceous margin, the others without metallic color; the second to fifth with straight hind margins, not emarginate, the sixth emarginate.

Osmia cyanopoda sp. n.

♀ Length nearly 10 mm., robust, deep indigo blue, the abdomen brilliant and shining; pubescence black, mixed with white on scutellum, and very slightly at sides of metathorax; antennæ black; femora and tibiæ strongly bluish or purplish; tegulæ with the anterior half blue; wings brown, paler along the veins; clypeus ordinary; mandibles tridentate; facial quadrangle longer than broad; mesothorax strongly and densely punctured; area of metathorax dull.

Habitat: Claremont, California (*Baker;* Pomona coll. 182). In the table in Ent. News, June, 1910, this runs to *O. gabrielis,* from which it is known by being smaller, face narrower, punctures of mesothorax distinctly larger and less crowded, scutellum with partly pale hair, and bluish tibiæ. The rich blue-purple color of the abdomen is exactly the same in both. Pomona coll. 181 (Mountains near Claremont, *Baker*) is *O. pogonigera* Ckll.

Osmia cyanosoma sp. n.

♀ Length nearly 7 mm.; deep indigo blue, the middle of the abdomen stained with greenish; hair black, mixed with fine short pale hairs on mesothorax; tuft behind wings, and hair at sides of metathorax and sides of first abdominal segment white; mandibles with two large sharp teeth and two minute ones. Very close to *O. tristella* Ckll., but separated by the partly pale hair on mesothorax, the distinctly metallic femora and tibiæ, tegulæ bright blue in front, hair of tarsi brownish, first r. n. joining second s. m. more remote from base. Also resembles *O. hypoleuca* Ckll. but is separated by the shorter second s. m., abundant black hair on scutellum, and black hair on tubercles. In *O. hypoleuca* there is a patch of glistening pale hair on lower part of pleura, and in *O. cyanosoma* there is

a similar patch, though less conspicuous. Another related but distinct species is *O. sanctæ-rosæ.*

Habitat: Mountains near Claremont, California (*Baker;* Pomona coll. 182, part). This may be a southern subspecies of *O. tristella.*

A totally different *Osmia* from Claremont (*Baker*), marked 182, is *O. novomexicana* Ckll., with the hair of the thorax above less brightly colored than in New Mexico specimens, but otherwise identical.

Osmia nigrobarbata sp. n.

♀ Length a little over 10 mm.; robust; head, mesothorax and scutellum dark green; pleura and metathorax much bluer; abdomen shining greenish-blue; legs black, without metallic tints; head broad; eyes pea-green; mandibles tridentate, the teeth very large; clypeus black (except borders), with dense coarse black hair, contrasting with pure white hair on sides of face; front and vertex with hair mixed black and white; upper part of cheeks with white hair, lower with more or less black; flagellum short, very obscurely reddish beneath; mesothorax and scutellum with extremely dense small punctures; area of metathorax shining except basally; mesothorax with thin white hair, with some black intermixed; tubercles with pale hair, but pleura with black; scutellum with abundant creamy hair, a few black intermixed; metathorax with black hair on lower part of sides, otherwise with pale; legs with black hair, more or less brownish on tarsi, a small tuft of pure white on posterior knees; tegulæ black, green in front; wings brownish, especially the broad apical margin; first r. n. joining second s. m. at a distance from its base equal to length of first t. c.; abdomen with white hair on first segment, scanty black hair beyond, but grayish-white on sixth and apical margin of fifth; scopa black.

Habitat: Claremont, California (*Baker;* Pomona coll. 182, part). Easily known by the contrasting black and white hair on face. It resembles *O. senior* Ckll., but differs by the shining area of metathorax, tridentate mandibles with large teeth, etc.

Osmia melanopleura sp. n.

♀ Length about 7.5 mm.; dark blue-green, densely punctured but somewhat shining; facial quadrangle longer than broad; mandi-

bles tridentate, the teeth large; clypeus extremely densely punctured; head with mixed white and black hair, the white conspicuous at sides of face, the black especially abundant on lower half of clypeus; antennæ black; thorax above with creamy-white hair, with black sparsely intermixed; metathorax with light and dark hair mixed; pleura with black hair (no patch of light hair below); legs black, with mainly black hair; tegulæ black, with a green spot in front; wings dilute brownish; b. n. meeting t. m.; first r. n. joining second s. m. as far from base as length of first t. c.; abdomen shining, the first two segments with glistening white hair, the next three with very thin light and dark hair, the sixth appearing greenish (contrasting with the rich purple-blue of the fifth), and hoary with appressed white hair; scopa black.

Habitat: Claremont, California (*Baker;* Pomona coll. 182, part). Resembles *O. pikei* Ckll., but differs by the much more finely punctured clypeus, the much shorter vertex, the much more closely punctured abdomen, etc.

The following key separates the above mentioned species of *Osmia;* all females with black ventral scopa.

	Hair of thorax above wholly or mainly black	1
	Hair of thorax above wholly or mainly light	3
1.	Very small, not quite 7 mm. long	*cyanosoma* sp. n.
	Larger	2
2.	Tibiæ dark blue	*cyanopoda* sp. n.
	Tibiæ black	*pogonigera* Ckll.
3.	Small, about 7.5 mm. long	*melanopleura* sp. n.
	Larger	4
4.	Hair of thorax above all pale ochreous	*novomexicana* Ckll.
	Hair of thorax above with some dark intermixed	*nigrobarbata* sp. n.

Nomada crotchii nigrior Ckll.

This was described from the female. The male (Claremont, *Baker*) has no red on the thorax, but there are four small creamy-white spots, two at the anterior corners of scutellum, and two on postscutellum. Clypeus all cream-colored except upper edge; third antennal joint little over half length of fourth; legs with more

black; abdomen with sublateral dark spots; apical plate minutely notched.

Nomada pyrrha sp. n.

♀ Length about 8 mm.; bright ferruginous red, without yellow markings, and practically without dark ones; mandibles simple; head very broad; third antennal joint a little longer than fourth; black between ocelli; mesothorax densely roughened, with three faintly indicated bands of darker red; post scutellum not yellow; metathorax with a dusky shade in middle below the enclosure; face, scape and front with scattered long fuscous hairs; thorax above practically hairless; sides of metathorax with a patch of white hair; a black patch near bases of middle and hind legs; tegulæ bright red, punctured; wings dilute brown, darker at apex; stigma ferruginous, nervures fuscous; b. n. going a considerable distance basad of t. m.; third s. m. much narrowed above; hind tibiæ roughened on outer side, but not distinctly tuberculate; abdomen dullish, minutely granular; sides apically with fuscous hair; fifth segment with a narrow band of shining white tomentum.

Habitat: Claremont, California (*Baker;* Pomona coll. 169). Closely resembles *N. californiæ* Ckll., but is evidently an entirely red *Xanthidium,* to be associated with *N. miniata* Sm., which however, has the third antennal joint much shorter than the fourth, and orange spots on the abdomen.

Nomada melanosoma sp. n.

♂ Length a little over 5 mm.; black, the body almost without light markings; hind margins of abdominal segments (fully half of second and third) obscurely brown; extreme sides of segments 2 to 5 with very oblique broad white stripes; mandibles simple, white at base; lower edge of clypeus very narrowly reddish, with a white mark on each side; malar space white; head broad; face covered with silvery-white hair; antennæ long, the flagellum thick, the joints swollen, obscure dark reddish beneath; third antennal joint about half length of fourth; vertex, cheeks and thorax (especially pleura and metathorax) with white hair; mesothorax dull, extremely densely rugoso-punctate; anterior legs in front, middle tarsi and apical part of femora in front, and apex of hind femora

in front, brownish-ferruginous; anterior femora with a whitish spot just before apex; tegulæ very dark reddish-brown; wings long, stigma (which is large), and nervures piceous; apex of wings strongly dusky; b. n. falling short of t. m.; abdomen dull, only the extreme margins of the segments glistening; shape of abdomen rather long-oval, wide in middle; apical plate deeply notched; venter, except at base, marked with white.

Habitat: Mountains near Claremont, California (*Baker;* Pomona coll. 171). A distinct little species, easily known by its color. It falls close to *N. obscurella* Fowler, but that is larger (7.5 mm.), with legs largely yellow, including the middle and hind basitarsi, which are entirely black in *melanosoma.*

Nomada subvicinalis Cockerell.

Two males from Claremont (*Baker*) differ a little from the type. One has small yellow spots at anterior corners of scutellum, lateral margins of mesothorax very narrowly reddish, lateral face-marks continued as slender lines part way up sides of front, and apical plate of abdomen quite broad. The other lacks the yellow patch on second ventral segment.

Nomada civilis Cresson.

Two males from Claremont (*Baker*) are peculiar for having the apical plate of abdomen entire. One is about 9 mm. long, and has large yellow spots on the metathorax. The other is about 7 mm. long, and has the metathorax all black. *N. civilis* is one of the most variable of bees, but it appears difficult to satisfactorily define subspecies. *N. edwardsii* Cress. is another yellow and black species found by Baker at Claremont.

Nomada erythrospila sp. n.

♂ Length about 7 mm.; long and slender; head and thorax black, with white hair, abundant on face, pleura and sides of metathorax; head transversely oval; front, mesothorax and scutellum dull and rugose; mandibles simple, pellucid white at base, fulvous in middle, and dark at apex; labrum creamy-white, covered with white hair; lower margin of clypeus and lower corners of face (with a linear extension upward along orbits) cream-color; an-

tennæ very long, third joint about half length of fourth; scape black; flagellum fulvous beneath, suffusedly blackened above; tubercles yellow, two minute yellow dots at anterior corners of scutellum, and two yellow spots on postscutellum, all these markings inconspicuous; legs black and ferruginous, some of the markings characteristic; the anterior tibiæ red with a black stripe on outer side, at the end of which is a cream-colored spot; the middle femora red in front, with a large black basal patch; the middle tibiæ red with a broad black band on outer side, and an apical cream-colored spot in front; the hind knees creamy-white; tegulæ ferruginous; wings reaching about to end of fourth abdominal segment, dilute brownish with a large clear patch in the subapical field; stigma dark, dusky red; b. n. going a little basad of t. m.; abdomen long and narrow, dull ferruginous, the segments with broad dark basal bands; segments 1 to 4 with large (largest on second) lateral creamy-white patches, the first two short and broad, the other two transversely elongate, each having upon it a clear red spot; fifth segment with the pale patches almost joined in middle, sixth with a broad pale band covering nearly all the surface; apical plate deeply notched; venter ferruginous with whitish and dusky markings.

Habitat: Claremont, California (*Baker;* Pomona coll. 172). A distinct little species of *Nomada* s. str. The abdominal markings suggest *N. crotchii* Cress., the male of which is not known, but the male of *N. crotchii nigrior* differs from *erythrospila* so much in form and face-markings, that we can hardly refer the latter to *crotchii.* In *N. crotchii* the first r. n. joins the second s. m. far beyond the middle, but in *erythrospila* it joins it at the middle. *N. marginella* Ckll., is allied to *N. erythrospila,* but the antennæ are quite different.

Nomada odontocera sp. n.

♂ Length a little over 7 mm.; rather robust, head and thorax black, densely rugosopunctate, but the large punctures of the mesothorax glistening; hair of head and thorax above pale fox-red, beneath dull white; head transversely oval; mandibles simple, yellow, red at apex; labrum yellow, not dentate; clypeus (except narrow upper margin) and lateral marks yellow, the latter extending

upward as rather narrow bands to about level of antennæ; scape stout, entirely yellow in front; third antennal joint much shorter than fourth, but more than half its length; flagellum thick, bright ferruginous beneath, black above, the joints conspicuously denticulate; tubercles yellow, but thorax otherwise all black; anterior coxæ unarmed; legs mainly red, but anterior and middle femora yellow in front, anterior femora black beneath, middle femora black behind except at apex; hind femora black, with the knees red, and a yellow spot at apex in front; hind tibiæ suffusedly blackish behind; tegulæ light ferruginous; wings ample, dusky at apex, stigma clear red; b. n. going a little basad of t. m.; first r. n. joining second s. m. well beyond middle; abdomen bright ferruginous marked with black and bright yellow; first segment black with a broad red band on which are two obscure dusky spots; all the segments with fuscous hind margins, second and third segments intense black at base; second to fifth segments laterally with yellow spots, very large on second, successively smaller on the others; sixth segment red; apical plate strongly notched; venter with two yellow spots on second segment.

Habitat: Mountains near Claremont, California (*Baker;* Pomona coll. 168). Allied to *N. undulaticornis* Ckll., but easily distinguished by the scutellum, which is not prominent or bigibbous, and by many details of the coloration. Also related to *N. denticulata* Rob.

N. elegantula Ckll. was also taken by Baker at Claremont.

Exomalopsis velutinus sp. n.

♀ Length about 9 mm.; black, with a rather long, not subglobose, abdomen; head broad, facial quadrangle broader than long; eyes gray; blade of maxilla broad to end, the inner half (longitudinally) pallid; labrum densely covered with pale ochreous hair; clypeus densely rugosopunctate, the lower margin dark red; face and front with long dull white hair; vertex smooth and polished; flagellum bright chestnut red beneath, except at base; thorax with pale ochreous-tinted hair; mesothorax polished, shining, with scattered punctures, only hairy at front and sides, and narrowly on hind margin; scutellum with similar sculpture and hairy border, but more closely punctured, and some short black hairs bordering

the disc; base of metathorax roughened but glistening; legs densely hairy, the hair pale ochreous-tinted; hind tibiæ and basitarsi with a very broad loose scopa, hair on inner side of hind basitarsi pale ferruginous; tegulæ piceous; wings rather short, faintly grayish, with a milky appearance in certain lights; greater part of abdomen densely covered with felt-like very pale ochreous pubescence, but apex with pale ferruginous; base of second segment with the hair so thin as to leave a dark band; first segment bare in middle, finely punctured; hind margin of first segment (tegument) broadly reddened, and the second and third the same, only in these the color is hidden by the pubescence; venter with bands of red-golden hair alternating with pale.

Habitat: Claremont, California (*Baker;* Pomona coll. 153). Very like *Melissodes stearnsi* Ckll., which is to be called *Exomalopsis stearnsi,* but readily distinguished by the shorter and relatively broader marginal cell, the well though finely punctured disc of first abdominal segment, and the much shorter third antennal joint (length 480 microns in *stearnsi,* 350 microns in *velutinus*). The apical plate of abdomen is much broader than in *stearnsi,* with straight sides. Both species look like some *Xenoglossodes,* from which the most conspicuous superficial distinction is the bare polished disc of mesothorax. A second specimen of *E. velutinus* bears the number 147.

Exomalopsis melanurus sp. n.

♀ Length about 8 mm.; black, abdomen oblong; light hair ochreous-tinted dorsally, dull white below; head broad; eyes pale grayish-green; mandibles red in middle; clypeus densely and strongly punctured; face and front with grayish-white hair; vertex shining; flagellum dusky ferruginous beneath except at base; mesothorax and scutellum with sculpture and arrangement of hair as in *E. velutinus;* legs with long pale hair, the copious scopa of hind legs wholly pale; a black brush at end of hind basitarsi; tegulæ piceous, wings faintly dusky; first abdominal segment with long pale hair, the broad hind margin bare except at sides, where there is a dense patch of hair, extreme margin (tegument) pallid; segments 2 to 4 with very broad dense felt-like ochreous hair-bands, the basal part of the segments exposed and appearing black; fifth segment and

apex densely covered with brownish-black hair, but there is a tuft of light hair on each side beneath.

Habitat: Claremont, California (*Baker;* Pomona coll. 148). This looks like *Anthophorula bruneri* Crawf., but is at once separated by the roughened disc of first abdominal segment, the black hair at end of abdomen, and the minute dark stigma; there is evidently no real affinity.

Melissodes pygmæa Cresson, from the description, is apparently an *Anthophorula* or *Exomalopsis;* indeed the description might well apply to *A. bruneri.*

E. velutinus and *E. melanurus* are not typical *Exomalopsis.* The genus as at present understood contains some rather diverse elements.

Bombomelecta maculata (Viereck)

Viereck described this as a variety of *B. separata,* but it seems to be a distinct species. A female from Claremont (*Baker;* Pomona coll. 162), has the spots on third and fourth segments quite large and quadrate, and there are small spots on the fifth.

Coelioxys megatricha sp. n.

♂ Length about 11 mm.; black, with bright ferruginous legs (the femora dusky beneath) and rather dark red tegulæ; no red on abdomen, above or below; mandibles dark red subapically; face and front densely covered with long white hair; antennæ black, third joint distinctly longer than fourth; vertex with very large punctures, which laterad of the ocelli are distinctly separated, leaving interspaces equal to the size of punctures; eyes pea-green, with very long hair; mesothorax and scutellum densely and very strongly punctured, middle of mesothorax with little longitudinal ridges; scutellum rounded behind, teeth at sides long, finger-like, slightly incurved; pleura and metathorax covered with long shaggy white hair; anterior coxæ with strong spines; anterior trochanters and femora with much white hair beneath; spurs red; wings clear, the apical margin broadly dusky; abdomen with white hair-bands at apices of segments; dorsum and sides of first segment closely punctured; second and third segments with very deep transverse impressions, and strongly punctured, the ridge just behind the impression with sparse punctures;

fourth and fifth segments with large triangular elevated areas, which are rather sparsely punctured; fifth segment with a small tooth on each side; sixth with dense white hair at base, at each side a long sharp tooth, the apical lobes far apart, each with two teeth, the upper short, little more than a salient angle, the lower long, flattened, rounded at end, divergent; fourth ventral segment not emarginate.

Habitat: Claremont, California (*Baker;* Pomona coll. 195). I wondered whether this could be the undescribed male of *C. coquilletti* Crawf., but it is larger than the male of that species would probably be, there are no hair bands bounding mesothorax or scutellum posteriorly, the vertex is not entirely rugose, and the abdomen is without red. From *C. novomexicana* it is easily known by the hair on eyes being more than twice as long. By the long hair on the eyes it resembles *C. ribis kincaidii* Ckll., which has black legs, and the apical teeth of abdomen closer together and almost parallel.

Coelioxys angulifera sp. n.

♀ Length about 11.5 mm.; black, strongly punctured, with white hair; lower margin of clypeus angularly produced and sloping a little outward; knees, tibiæ and tarsi dark red, the tibiæ with a strong blackish suffusion. Very close to *C. banksi* Crawf. (from Virginia), differing thus: teeth at sides of scutellum long; no band of white hair in scutello-mesothoracic suture; mesopleuræ with long hair (not very dense) all over; last ventral segment not so much extended beyond last dorsal. Except for the clypeus, it much resembles *C. moesta* Cress., differing in the much longer teeth at sides of scutellum, and much larger punctures at base of penultimate ventral segment.

♂ Length about 8 mm.; face and front densely covered with white hair; anterior coxæ with well-developed spines; legs darker, the tibiæ mainly blackish; fifth abdominal segment with a short spine on each side; sixth with a long spine on each side, and the apical lobes each with two spines, the upper much shorter than the lower; no median spine; fourth ventral segment entire. In my table of male *Coelioxys* (Canad. Entom., 1912, p. 170) this runs to *C. angelica* Ckll., the female of which is very different from *C. angulifera.*

Habitat: Claremont, California (*Baker;* Pomona coll. 195). The female is the type. Were the insects not separated by the whole breadth of the continent, I should suppose this a race of *C. banksi. C. novomexicana* (Ckll.) was also taken by Baker at Claremont.

Xenoglossa angelica Ckll.

Claremont (*Baker;* Pomona coll. 145.)

Tetralonia robertsoni Ckll.

A female from Claremont (*Baker;* Pomona coll. 153) agrees with one from Garrison, N. Y. Can there be any error in the locality label?

Ceratina neomexicana punctigena subsp. n.

♀ Length about 8 mm.; differs from typical *neomexicana* by the cheeks, which are strongly and quite closely punctured, except a narrow band along orbits. The wings are strongly reddened, and the mesothorax is sparsely punctured anteriorly. It is known from the superficially similar *C. tejonensis* Cress. (which Baker obtained at Claremont) by the green (rather than blue) color, the white tubercles, and the strongly punctured cheeks.

Habitat: Mountains near Claremont (*Baker;* Pomona coll. 174). Baker also took *C. acantha* Prov. and *C. arizonensis* Ckll. at Claremont.

Anthidium angelarum Titus

Both sexes were taken by Baker at Claremont, Calif. The male, not described by Titus, runs to *A. palliventre* in my table in Bull. So. Calif. Acad. Sci., 1904, p. 57. It differs from the insect there referred to *palliventre* by the bright chrome yellow markings and the distinct rounded excavation on each side of median spine at apex of abdomen. The clypeus and large cuneiform lateral marks are entirely yellow. The female has yellow stripes on tibiæ, not mentioned by Titus.

A. illustre Cress. and *A. tricuspidum* Prov. were also taken by Baker at Claremont.

Dianthidium provancheri Titus

This is the species which I recorded as *D. consimile* (Ashm.) in Bull. So. Cal. Ac. Sci., 1904, p. 5. A specimen of true *consimile*

was collected by Baker in the mountains near Claremont. The males may be separated thus:

Outer face of hind tibiæ with a large black mark; yellow band of scutellum broadly interrupted in middle; median tooth at apex of abdomen black at end.....*provancheri* Titus.

Outer face of hind tibiæ entirely yellow; yellow margin of scutellum not interrupted; median tooth at apex of abdomen long and entirely yellow.....*consimile* (Ashm.)

A male with pale markings, collected by Grinnell in the San Gabriel Mts., has the hind tibiæ as in *provancheri,* but the light band on scutellum, though narrow, is entire, and the median tooth at end of abdomen is rather brown than black at end. This is referred to *provancheri,* but it may be that the two names represent extremes in the variation of a single species.

Triepeolus ancoratus sp. n.

♀ Length about 8 mm., with ochreous markings and red tegulæ and legs. Very near to *T. callopus* Ckll., but smaller; mesothorax with two broad bands and margin with ochreous pubescence, leaving only an anchor-shaped black area; cheeks and front densely covered with pubescence; antennæ red, dusky above, especially the hind margins of joints; pleura with no bare patch. The mandibles, labrum, lower margin of clypeus and apex of abdomen are red, as in *T. callopus.* The black transverse band on first abdominal segment is completely isolated by dense ochreous pubescence; the black on second segment forms a very acute angle at sides. The last ventral segment is turned down at end.

Habitat: Claremont, Calif. (Pomona coll. 155). Certainly very near to *T. callopus,* but quite distinct by the characters indicated. Collected by Baker.

Triepeolus callopus Ckll.

One of each sex comes from Claremont (*Baker;* Pomona coll. 157, 158). The male is new. I give new descriptions, based on these specimens.

♀ Length about 7.5 mm.; black, with clear red legs (but spurs of middle and hind legs black); clypeus, labrum, mandibles (except apex), tubercles, tegulæ (except hyaline margin) and apex of abdo-

men also red; light markings dorsally pale creamy, ventrally white; head broad; clypeus minutely granular; antennæ red strongly suffused with blackish, apex of scape and base of flagellum brighter red; third joint shorter than fourth; front and vertex more or less striate; mesothorax very densely and minutely punctured, with two parallel bands of pale ochreous hair, a spot of hair at each posterior corner, and a band in scutello-mesothoracic suture; pleura with a large bare densely punctured patch; scutellum rather strongly bilobed; axillar teeth very short; wings somewhat dusky, brownish; abdomen with broad, continuous light ochreous bands on segments 1 to 4, that on first notched in middle anteriorly; black area on first segment a broad transverse band; light band on second segment with a large oblique lobe (directed mesad) laterally, giving the outline of a scythe; modified apical patch rounded; last ventral segment curved downward at end.

♂ Clypeus all black; scape black; flagellum dusky reddish, without any bright red; face with dense white hair; tubercles black; pleura with a bare patch just below wings, but the lower bare patch small and indistinct; femora black, with red knees; hind margins of second and following abdominal segments brownish; apical plate extremely narrow.

Three New Chalcid Flies From California

By A. A. Girault.

(Material for this paper was sent from the Zoological Department of Pomona College.)

Sympiesomorphelleus californicus, New Species.

Female: Similar to *nigriprothorax,* but twice larger and differing as follows: The stripe along the meson of the abdomen is narrower and is joined narrowly to base; the propodeum is all metallic green except narrowly along the median carina and broadly at mesal apex. The rectangular sclerite laterad of the postscutellum is metallic. There is a more distinct metallic spot near tegulæ. There is an oblique metallic stripe across the mesopleurum from the base of the caudal wing and an area of irregular shape on the mesopleurum over the cephalic coxa; also the cephalic third of the scutum is dark metallic, like the prothorax, and the scape is entirely black. Otherwise the same. The third joint of the club is nipplelike and may be articulated.

Described from two females from Claremont, California (C. F. Baker).

Types: Catalogue No. 20172, U. S. N. M., the above specimens on tags, a head and a caudal tibia on a slide.

The species *nigriprothorax* has the margins of the abdomen black; the parts mentioned in the original description of it are dark metallic.

Zagrammosoma mira new species.

Female: Very similar to *flavolineata* Crawford, but the abdomen bears no yellow spots, the entire caudal femur is metallic purple except at apex (only with a cinctus distad of middle in the other species), the extreme base of caudal tibia is more distinctly purple, the caudal coxa has more than a purple spot above at base, its basal third or more is purple, the yellow median stripe of the thorax is narrower and more uniform in width, the distal stripe of the fore wing is nearly or quite complete, though fainter coudad; there is no narrow longitudinal yellow stripe down parapside and axilla; and

also, the margin of abdomen ventro-laterad near base is not yellow; otherwise remarkably alike. In *flavolineata* there is a rather large area on lateral propodeum just cephalad of the caudal coxa (the propodeum laterad of the minute spiracles) and which has an oblique, narrow purple stripe at its meso-caudal corner; this is absent in this species. Both species bear a moderately long median carina on the propodeum, the latter *distinct*. In both species the vertex is purple nearly to each eye (between the lateral ocelli), and this is due to a broad purple stripe up the meson of the occiput which below the center (at the neck) divides and goes over to the eye where each arm divides again; but in *flavolineata* the small Y at the eye is broadly separated from the parent marking; one arm of this Y, the broader, meets the eye above the ventral apex on the occipital aspect, the other goes to the ventral apex of the eye, across the cheek. Description of *flavolineata* otherwise correct. On the vertex cephalad the purple apparently gives off a branch latero-cephalad, one (a very short one) going to the dorsal apex of the eye, the other down the face along the eye for some little distance; a very narrow median stripe on face between the antennæ and the mouth (the narrow median black stripe of *flavolineata*). Mandibles six-dentate. Scape lemon yellow at proximal half except above; club three yellowish.

From one female taken on the mountains near Claremont, California (C. F. Baker).

Type: Catalogue No. 20089, U. S. N. M., the specimen on a tag, the head, a caudal tibia and a pair of wings on a slide.

Pseudiglyphomyia unguttatipennis new species.

Female: Of the stature and general appearance of *flavicinctus*. Dark metallic green, the following parts bright lemon yellow: Legs (except a broad central cinctus on middle tibia and the hind coxæ), head (except ocellar area and upper three-fourths of the occiput), a round spot ventrad of middle of propleurum, a broad stripe across the dorsal and lateral and ventral thorax through the fore coxæ (including somewhat less than the distal half of the scutum, the parapside entirely and much of the cephalic meso-pleurum); cephalic half of lateral and mesal margins of axillæ; the distal fifth of abdo-

men, the yellow triangularly produced at meson and two cross-stripes on abdomen near base, the first narrowly interrupted at the meson. Fore wings hyaline but centrally with a large round moonlike spot, whose center is opposite the distal part of the marginal vein, the stigmal vein not extending distad of its most distal circumferential point; postmarginal vein distinctly shorter than the stigmal, the venation yellow. Antennæ dull brownish yellow, the scape and pedicel metallic green (except bulb and base of the former and apex and ventral side of the latter). Funicle 1 two-thirds longer than wide, subequal to the pedicel, 2 a little longer than wide. Club with a distinct terminal spine. Mandibles 5-dentate.

Pronotum large, conical. Propodeum with a distinct median carina, otherwise plane, the spiracles minute. Thorax scaly.

Described from one female received from Wm. A. Hilton and collected at Laguna Beach, Southern California (C. F. Baker).

Type: Catalogue No. 20173, U. S. N. M., the female on a tag, the head, a caudal leg and a fore wing on a slide.

Perilampus chrysopæ Crawford.

Three females, Claremont, California (C. F. Baker). Compared with types.

Perilampus canadensis Crawford.

This belongs in the first division of Crawford's (1914) table, and is closely allied with *subcarinatus;* but in the latter the lower face (laterad of the clypeus) is finely cross-wrinkled, but in *canadensis* it bears only a few punctures (and a line of smaller punctures up the eye margin); the lower cheeks are similarly sculptured for the respective species (that is, in *subcarinatus* finely striate, and so on). The carina referred to in the table is the carinated edges of the large scrobicular cavity (with the species bearing it, the face is striate, otherwise smooth or mostly so). The carina is weak in *robertsoni,* which resembles *similis,* but there is more sculpture on the head in the former; in *robertsoni* the venation is pale, black in *similis.* The species *subcarinatus* and *platygaster* are very much alike, but the latter has larger punctures on the clypeus and the lateral margin is cross-wrinkled, while in the first species the clypeus is practically smooth and with minute scattered punctures; more-

over, the venation in *platygaster,* is very pale and the parapsides caudo-mesad finely reticulated (glabrous in the other species). The carina on the face is a good character, but great care must be taken that it is seen; it may be rather close to the eye (*i. e.,* the long facial part of it). Types of *canadensis, subcarinatus, similis, robertsoni* and *bakeri* examined.

The species *bakeri* and *subcarinatus* are synonyms.

A Rare Fish From Laguna Beach

A photograph of this fish was sent to Prof. Gilbert to whom we are indebted for the identification. The specimen was caught on a hook and line not far from the laboratory. It was brought in by Prof. A. M. Bean. No one in Laguna had ever seen anything like it and no one would venture an opinion as to what it was.

Alepisaurus æsculapius Bean

Color, dark slaty gray above, sides silvery and irridescent, back steel blue reflections. Under parts a lighter gray silvery. Adipose, pectoral and caudal fins nearly black. Skin smooth, apparently without scales.

Total length 101 cm. Length of head from tip of mouth to the back of the operculum 17 cm. Pectoral fin just back of operculum, beginning of the dorsal just over it. Length of snout to front of eye 6.6 cm. Eye 3.5 cm. long by 2.8 high. Breadth of pectoral at base 2.8 cm. Fin rays of pectorals at base 14 in number, the first and last are small, all the others branched. The first branch of the 4th to the 13th is branched again. The fifth ray with its branches is the longest, those on either side are quite long, so that the fin ends in one or several long streamers. Greatest length of fin 16.5 cm.

Distance between back of fore fin and front of pelvic 19.2 cm. Pelvic fins 8 rays, first and last not branched, membrans as on all fins delicate and easily broken. Length of fin 5.7 cm. Anal opening 3 cm. from back of anal fins, ½ cm. long, not quite so wide. Distance from pectoral to anal fin 30 cm. Length of anal 10.8 cm. 17 fin rays all branched but first and last, the first branch of each branched again. Longest part of fin (slantingly taken) 8 cm., one to the 6th fin rays nearly as long.

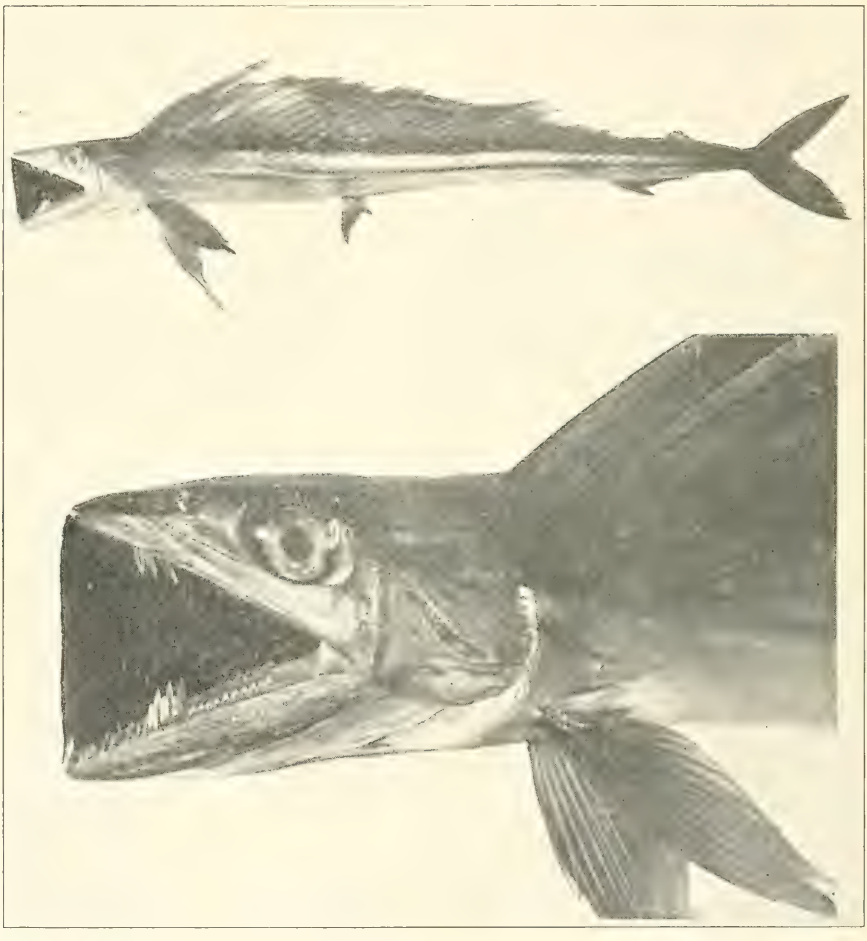
Tail symmetrical short rays in center, about 2 cm. long, at outer margin longest about 14 cm., about 40 fin rays in the tail.

Dorsal fin about 58 cm. long, 34 fin rays unbranched. Most of the fin rays are long, 10 to 19 cm. Height of the fin through most of its distance 9 cm.

Adipose fin 7.5 cm. from the dorsal at its base, ½ cm. broad at its attachment, length 3 cm.

Side and ventral region of the head:

Length of the mouth opening, 11.5 cm. Slit of gular fold, 6.5 cm. from tip of lower jaw. Gular slit to end of operculum, 10 cm.



Head narrow at level of the eyes; above it is 3.2 cm. Head at widest above is 3.5 cm. at the level of the eyes; back of this it is hardly more than 2 cm. Tip of jaw above, .5 cm. Tip of snout to nostril, 3.5 cm. Nostril, .5 cm. in diameter. Distance from nostril to eye, 2.8 cm. Whe nthe mouth is closed the lower jaw projects a

little. The lower jaw has two short, sharp teeth in front when the mouth is closed. When it is open there is a large tooth, .8 cm. long. The lower jaw hsa, next, ten teeth 1 cm. long, then three large ones 3 cm. long, then ten trinagular teeth 1 cm. long. The upper jaw has an outer row which may be seen when the mouth is closed. These are 1 cm. or less in length and 75 on a side. The roof of the mouth has three projecting teeth like the large ones below, knife-shaped, flattened from side to side, 3 cm. long. Back farther, on each side, is a similar tooth 1 cm. long, then on each side a similar tooth 1 cm. long, then on each side back six triangular teeth 3 mm. long.

The three large central teeth should really be counted four, because there is another of the same sort not yet fully broken through the membrane of the mouth.

Greatest depth of the head is 8 cm. The body was much shrunken after preservation, but the proportionate depth at various regions is well shown in the photograph which was taken by our photographer, E. M. Robbins.

W. A. Hilton.

(Contribution from the Zoological Laboratory of Pomona College)